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Date: SEP 06 2016
Refer To: ADEM-16-5234
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Locates Action No.: n/a

John Kieling, Bureau Chief
Hazardous Waste Bureau
New Mexico Environment Department
2905 Rodeo Park Drive East, Building 1
Santa Fe, NM 87505-6303

Subject: Groundwater Investigation Work Plan for Consolidated Unit 16-021(c)-99, Including Drilling Work Plans for Wells R-68 and R-69

Dear Mr. Kieling:

Attached please find two hard copies with electronic files of Groundwater Investigation Work Plan for Consolidated Unit 16-021(c)-99, Including Drilling Work Plans for Wells R-68 and R-69.

This work plan has been developed to address data needs identified based on new and emerging information from recent characterization activities at Technical Area 09 (TA-09) and TA-16 related to Consolidated Unit 16-021(c)-99, also known as the 260 Outfall. The work and approach proposed in the plan reflect pre-submittal discussion the staff of the New Mexico Environment Department (NMED). The plan includes the installation of up to two regional aquifer monitoring wells north of Cañon de Valle to support the investigation of RDX (hexahydro-1,3,5-trinitro-1,3,5-triazine) in groundwater at TA-09 and TA-16. Data collected from the proposed well(s) will be used to revise the corrective measures evaluation report for intermediate and regional groundwater at Consolidated Unit 16-021(c)-99.

The June 2016 Compliance Order on Consent requires the submittal of the updated corrective measures evaluation (CME) report by September 30, 2017. If approved, the scope conducted under this work plan would require a separate request to NMED for an extension to the current due date for the CME that reflects the implementation schedule for this work plan. Because of seasonal habitat impacts to work schedules and the need to collect the first set of data as soon as possible, Los Alamos National Laboratory requests that NMED expedite review of this work plan within 30 days of receipt.

If you have any questions, please contact Stephani Swickley at (505) 606-1628 (sfuller@lanl.gov) or Cheryl Rodriguez at (505) 665-5330 (cheryl.rodriguez@em.doe.gov).

Sincerely,

Bruce Robinson, Program Director
Environmental Remediation Program
Los Alamos National Laboratory

Sincerely,

David S. Rhodes, Director
Office of Quality and Regulatory Compliance
Environmental Management
Los Alamos Field Office

BR/DR/SV:sm

Attachment: Groundwater Investigation Work Plan for Consolidated Unit 16-021(c)-99, Including Drilling Work Plans for Wells R-68 and R-69 (EP2016-0109)

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LA-UR-16-26493
September 2016
EP2016-0109

Groundwater Investigation Work Plan for Consolidated Unit 16-021(c)-99, Including Drilling Work Plans for Wells R-68 and R-69

Los Alamos
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EST. 1943

Prepared by the Associate Directorate for Environmental Management

Los Alamos National Laboratory, operated by Los Alamos National Security, LLC, for the U.S. Department of Energy (DOE) under Contract No. DE-AC52-06NA253 and under DOE Office of Environmental Management Contract No. DE-EM0003528, has prepared this document pursuant to the Compliance Order on Consent, signed June 24, 2016. The Compliance Order on Consent contains requirements for the investigation and cleanup, including corrective action, of contamination at Los Alamos National Laboratory.

EP2016-0109

Groundwater Investigation Work Plan for Consolidated Unit 16-021(c)-99, Including Drilling Work Plans for Wells R-68 and R-69

September 2016

Responsible project manager:

Printed Name	Signature	Title	Organization	Date
Stephani Swickley	Stephani Swickley	Project Manager	Environmental Remediation Program	8/26/16

Responsible LANS representative:

Printed Name	Signature	Title	Organization	Date
Randall Erickson	R Erickson	Associate Director	Associate Directorate for Environmental Management	8/29/16

Responsible DOE-EM-LA representative:

Printed Name	Signature	Title	Organization	Date
David S. Rhodes	David S. Rhodes	Office Director	Quality and Regulatory Compliance	9-31-2016

CONTENTS

Figures

Appendixes

1.0 INTRODUCTION

This work plan has been developed to address data needs identified based on new and emerging information from recent characterization activities at Technical Area 09 (TA-09) and TA-16 related to Consolidated Unit 16-021(c)-99, also known as the 260 Outfall. The work proposed in the plan includes the installation of up to two regional aquifer monitoring wells north of Cañon de Valle to support the investigation of RDX (hexahydro-1,3,5-trinitro-1,3,5-triazine) in groundwater at TA-09 and TA-16. Data collected from the proposed well(s) will be used to revise the corrective measures evaluation (CME) report, hereafter the CME report, for intermediate and regional groundwater at Consolidated Unit 16-021(c)-99.

1.1 Background

The U.S. Department of Energy and Los Alamos National Security, LLC, submitted the original CME report in July 2007 and recommended a remediation strategy of monitored natural attenuation for the intermediate and regional groundwater, with possible pump and treat to reduce high explosives (HE) contaminant concentrations in groundwater (LANL 2007, 098734). NMED subsequently issued a notice of disapproval (NOD) for the CME report In April 2008 (NMED 2008, 101311). In the NOD, NMED required Los Alamos National Laboratory (LANL or the Laboratory) to conduct additional characterization to evaluate the feasibility of the remedial alternatives proposed in the CME and to assess the extent of groundwater contamination in perched-intermediate groundwater and in the regional aquifer.

In response to NMED's NOD, the Laboratory developed the "Supplemental Investigation Work Plan for Intermediate and Regional Groundwater at Consolidated Unit 16-021(c)-99" (LANL 2008, 103165), proposing additional characterization activities to address uncertainties in the hydrogeologic conceptual model at TA-16. These activities included installing additional perched-intermediate and regional groundwater monitoring wells, performing additional groundwater monitoring, and conducting single well aquifer tests to further characterize intermediate and regional groundwater. Subsequent work plans were submitted later proposing multiwell aquifer tests and cross-hole tracer tests (LANL 2012, 210352; LANL 2015, 600535; LANL 2015, 600686) to address hydrogeologic uncertainties. Activities subsequently completed in accordance with these work plans include the following:

- Installation and monitoring of perched-intermediate monitoring wells R-25b, R-25c (dry), R-47i, R-63i, CdV-9-1(i), and CdV-16-4ip
- Installation and monitoring of regional monitoring wells R-48 and R-58
- Reconfiguration of wells CdV-R-37-2 and CdV-R-15-3 from Westbay sampling systems to single-screened wells with purgeable sampling systems
- Conducting short-duration aquifer tests in new monitoring wells
- Conducting extended duration aquifer tests at CdV-16-4ip in 2011 and 2014
- Deploying groundwater tracers in perched-intermediate wells CdV-9-1(i) and its two piezometers and in R-25b and CdV-16-1(i)

Ongoing characterization activities include the following:

- Conducting routine sampling of monitoring wells, springs, and base flow
- Sampling for tracers in monitoring wells surrounding tracer-injection points

- Conducting extended-duration (30-d) cross-hole aquifer tests using CdV-9-1(i), CdV-16-4ip, and CdV-16-1(i) as pumping locations and monitoring the effects in surrounding wells
- Conducting bench-scale RDX degradation studies
- Conducting bench-scale RDX treatability studies to determine if enhanced bioremediation techniques can be used to degrade RDX under site-specific conditions at TA-16
- Refining the geologic conceptual model to explore stratigraphic controls on perched-intermediate groundwater flow direction
- Updating RDX mass distribution estimates based on information obtained from new wells
- Updating and refining hydrogeologic models of the 3-dimensional (3-D) distribution and connectivity of perched-intermediate groundwater
- Developing a 3-D numerical variably-saturated model simulating groundwater flow and contaminant transport at the site

New and emerging information from these characterization activities suggest additional data are needed to further refine the nature and extent of contamination in the regional aquifer and the conceptual model to support evaluation of remedial alternatives for RDX contamination. This new information includes the following:

- RDX concentrations in regional monitoring well R-18 have been increasing to approximately one-half the U.S. Environmental Protection Agency (EPA) tap water screening level of 7.0 µg/L, with the rate of increase accelerating over the past 2 yr, indicating expansion of RDX contamination in the regional aquifer (Figure 1.1-1). The screened interval at R-18 is approximately 69 ft below the water table, and concentrations of RDX could be higher near the water table at that location.
- Well R-18 exhibits a unique ratio of RDX to various high-explosives degradation products compared with other contaminated wells in the area. The degradation products detected in R-18 are generally associated with degradation of TNT (2,4,6-trinitrotoluene) and/or use of HE products such as Composition B, a mixture of TNT and RDX. In addition, the ratios of TNB (trinitrobenzene), a TNT degradation product and manufactured explosive compound, to RDX are elevated. These unique ratios could be a result of varying degradation rates along a long and complex pathway from the 260 Outfall (TNT was used more extensively during the early years of production at TA-16), or they could be related to machining of different types of HE at TA-09 than those machined at TA-16. Archival information indicates that TA-09 could be a possible source of RDX contamination observed at R-18 (Baytos 1985, 058910). Given the proximity of R-47 to Cañon de Valle, and the fact that R-47 does not show RDX contamination, this could indicate that the contamination detected in R-18 may originate from a source other than the 260 Outfall, with one possibility being historical releases from TA-09.
- Screening data collected during drilling at perched-intermediate well CdV-9-1(i) indicate the presence of a thick (greater than 200 ft) saturated zone with RDX concentrations potentially as high as approximately 300 µg/L. This perched water was detected at an elevation of 6912 ft, considerably higher than other perched-intermediate zones identified to date. The next closest water level is 6794 ft at CdV-16-1(i), while the primary screen at CdV-9-1(i) has a water level of 6607 ft. The discovery of the high elevation of the perched-intermediate groundwater and associated elevated RDX concentrations is the first indication of significant perched-intermediate groundwater north of Cañon de Valle. This complex of perched groundwater zones could be part of the pathway that explains the increasing RDX trends observed in R-18.

In summary, the increasing contamination detected at R-18 can be explained in several ways, based on the new and emerging information discussed above.

- The contamination may originate from the 260 Outfall, migrating down from Cañon de Valle through the vadose zone to the regional aquifer, and then migrating northeast to R-18.
- The contamination may be related to the thick high-RDX perched zone believed to be present at CdV-9-1(i) in the interval between 650 ft and 900 ft bgs.
- The contamination may originate from an alternate source, possibly from historical releases at TA-09.

2.0 OBJECTIVES

This investigation work plan has been developed to address the following five objectives. These objectives are being addressed with installation of two regional aquifer wells north of CdV. The locations and further discussion of the specific objectives and drilling approach are addressed in the drilling work plans for wells R-68 and R-69 in Appendixes A and B, respectively, of this investigation work plan.

1. **Refine nature and extent of contamination in the regional aquifer**

   The first objective is to better define the extent of contamination in the regional aquifer north of Canon de Valle. The extensive perched-intermediate zone at CdV-9-1(i), increasing concentrations of RDX at R-18, and the potential for a TA-09 source warrant further characterization of the regional aquifer north of Cañon de Valle.

2. **Evaluate potential TA-09 source of HE contamination in the regional aquifer**

   The second objective is to evaluate possible TA-09 sources for HE contamination in the three HE outfalls at TA-09 (05A066, 05A067, and 05A068) that discharged into Bulldog Gulch from the mid-1950s to the mid-1990s (Figure 2.0-1). During the late 1970s, these outfalls were permitted by EPA to operate under the Laboratory's National Pollution Discharge Elimination System Permit (EPA 1990, 012454). Historical records suggest discharge volumes for the outfalls were on the order of up to millions of gallons per year, providing a potential mechanism for HE contaminants to migrate along Bulldog Gulch and possibly downward through the vadose zone and into the regional aquifer.

3. **Constrain regional water table north of Cañon de Valle**

   The third objective of this investigation is to constrain the regional water table north of Cañon de Valle. Figure 2.0-2 shows the current water-table map for the regional aquifer in the area of TA-16 and TA-09. The only control points for the regional aquifer north of Cañon de Valle are regional wells R-18 and R-47. These limited control points make evaluation of potential contaminant sources difficult. The two additional wells proposed will better constrain the data and allow more accurate assessment of groundwater flow velocity and flow direction.

4. **Characterize the (northern) extent of the contaminated perched-intermediate groundwater zone observed at CdV-9-1(i)**

   The fourth objective of this investigation is to collect additional data regarding the lateral extent of the contaminated perched-intermediate groundwater zone(s) north of Cañon de Valle. As shown in Figures 2.0-1 and 2.0-2, the lateral extent of perched-intermediate groundwater is not well

constrained north of Cañon de Valle. The highest concentrations detected to date in any of the perched-intermediate zones in the area of TA-16 were identified during drilling of CdV-9-1(i). If that zone becomes a key target for remediation, it will be useful to have constraints on its extent to the north of Cañon de Valle. In addition, if perched-intermediate groundwater is encountered, core may be collected from the perched-intermediate zone for laboratory studies on RDX retardation and biodegradation.

5. **Fill data gaps for regional aquifer performance monitoring**

   A fifth objective of this investigation plan will be to fill data gaps for regional aquifer performance monitoring that will be required for any CME remedial alternative. The CME will likely focus on corrective measures alternatives with a primary goal of protecting the regional aquifer. Based on the recent observations at CdV-9-1(i) and R-18 described above, the current configuration of the monitoring network is likely insufficient for monitoring performance of any of the potential remedies.

3.0 APPROACH

The proposed approach to this investigation is to install and sample well R-68 first and use the information gleaned from the project to evaluate whether the results satisfy the objectives described above. Key information that should be obtained from R-68 includes the concentration of RDX (and other HE compounds) in groundwater samples from the completed well, water-level information to refine the direction of groundwater flow in the regional aquifer, and the presence and nature of ratios of RDX to various degradation products. If this type of information strongly indicates contamination at R-18 is from Cañon de Valle, then it may be possible to proceed with preparing the CME without collecting data from R-69. The goal would be to obtain the initial sample from R-68 after development and aquifer testing, and one additional quarter of data to support the recommendation of whether drilling R-69 is still necessary to meet the objectives of this work plan and support the CME. Well R-69 would likely still be drilled to address a potential TA-09 source, but data from R-69 may not be necessary to proceed with the CME report.

The specifics of the drilling approach are presented in the drilling work plans in Appendixes A and B of this investigation work plan.

4.0 SCHEDULE

The proposed locations for R-68 and R-69 are within the buffer for Mexican Spotted Owl habitat, and therefore, work is prohibited starting in March of each year and extending to May. Because of the restrictions, the goal is to complete and collect the first sample from R-68 before February 28, 2017. A second sample would be collected in the May 2017 time frame. Ideally, four quarters of data are necessary to confirm the representativeness of the data from a newly installed well. Collection of four quarters of data requires a total of 9 mo beyond the first sample collected shortly after development and aquifer testing. Quick-turnaround analysis will be requested for the samples, so a recommendation can be made to NMED regarding R-69 by June 30, 2017. If drilling R-69 is necessary to fulfill the objectives of this investigation work plan, a specific completion date will be proposed at that time.

The June 2016 Compliance Order on Consent requires the submittal of the updated CME Report by September 30, 2017. The phased approach described above requires an extension from the September 30, 2017 due date. If R-69 is required and has a drilling schedule that begins in July 2017, the collection of four quarters of data will take until approximately May 2018, assuming the first round can be collected in August 2017. With the new date, a CME could be completed by September 30, 2018. Additional refinement of the submittal date may be warranted based on data from these wells.

5.0 REFERENCES

The following list includes all documents cited in this plan. Parenthetical information following each reference provides the author(s), publication date, and ER ID or ESH ID. This information is also included in text citations. ER IDs were assigned by the Environmental Programs Directorate's Records Processing Facility (IDs through 599999), and ESH IDs are assigned by the Environment, Safety, and Health (ESH) Directorate (IDs 600000 and above). IDs are used to locate documents in the Laboratory's Electronic Document Management System and, where applicable, in the master reference set.

Copies of the master reference set are maintained at the NMED Hazardous Waste Bureau and the ESH Directorate. The set was developed to ensure that the administrative authority has all material needed to review this document, and it is updated with every document submitted to the administrative authority. Documents previously submitted to the administrative authority are not included.

Baytos, J.F., August 7, 1985. "Analysis of Soil Samples for Residual Explosives from Drainage Ditches at Sump Effluent Outlets (for July 18, 1984)," Los Alamos National Laboratory memorandum to A.P. Torres (WX-3) from J.F. Baytos, Los Alamos, New Mexico. (Baytos 1985, 058910)

EPA (U.S. Environmental Protection Agency), 1990. "NPDES Authorization to Discharge Waters of the United States," Water Management Division, EPA Region 6, Dallas, Texas. (EPA 1990, 012454)

LANL (Los Alamos National Laboratory), August 2007. "Corrective Measures Evaluation Report, Intermediate and Regional Groundwater, Consolidated Unit 16-021(c)-99," Los Alamos National Laboratory document LA-UR-07-5426, Los Alamos, New Mexico. (LANL 2007, 098734)

LANL (Los Alamos National Laboratory), June 2008. "Supplemental Investigation Work Plan for Intermediate and Regional Groundwater at Consolidated Unit 16-021(c)-99," Los Alamos National Laboratory document LA-UR-08-3991, Los Alamos, New Mexico. (LANL 2008, 103165)

LANL (Los Alamos National Laboratory), January 2012. "Work Plan for a Tracer Test at Consolidated Unit 16-021(c)-99, Technical Area 16," Los Alamos National Laboratory document LA-UR-12-0440, Los Alamos, New Mexico. (LANL 2012, 210352)

LANL (Los Alamos National Laboratory), July 2015. "Work Plan for a Tracer Test at Consolidated Unit 16-021(c)-99, Technical Area 16, Revision 1," Los Alamos National Laboratory document LA-UR-15-24089, Los Alamos, New Mexico. (LANL 2015, 600535)

LANL (Los Alamos National Laboratory), August 2015. "Work Plan for Intermediate Groundwater System Characterization at Consolidated Unit 16-021(c)-99," Los Alamos National Laboratory document LA-UR-15-24545, Los Alamos, New Mexico. (LANL 2015, 600686)

NMED (New Mexico Environment Department), April 22, 2008. "Notice of Disapproval Corrective Measures Evaluation Report, Intermediate and Regional Groundwater Consolidated Unit 16-021(c)-99," New Mexico Environment Department letter to D. Gregory (DOE-LASO) and D. McInroy (LANL) from J.P. Bearzi (NMED-HWB), Santa Fe, New Mexico. (NMED 2008, 101311)

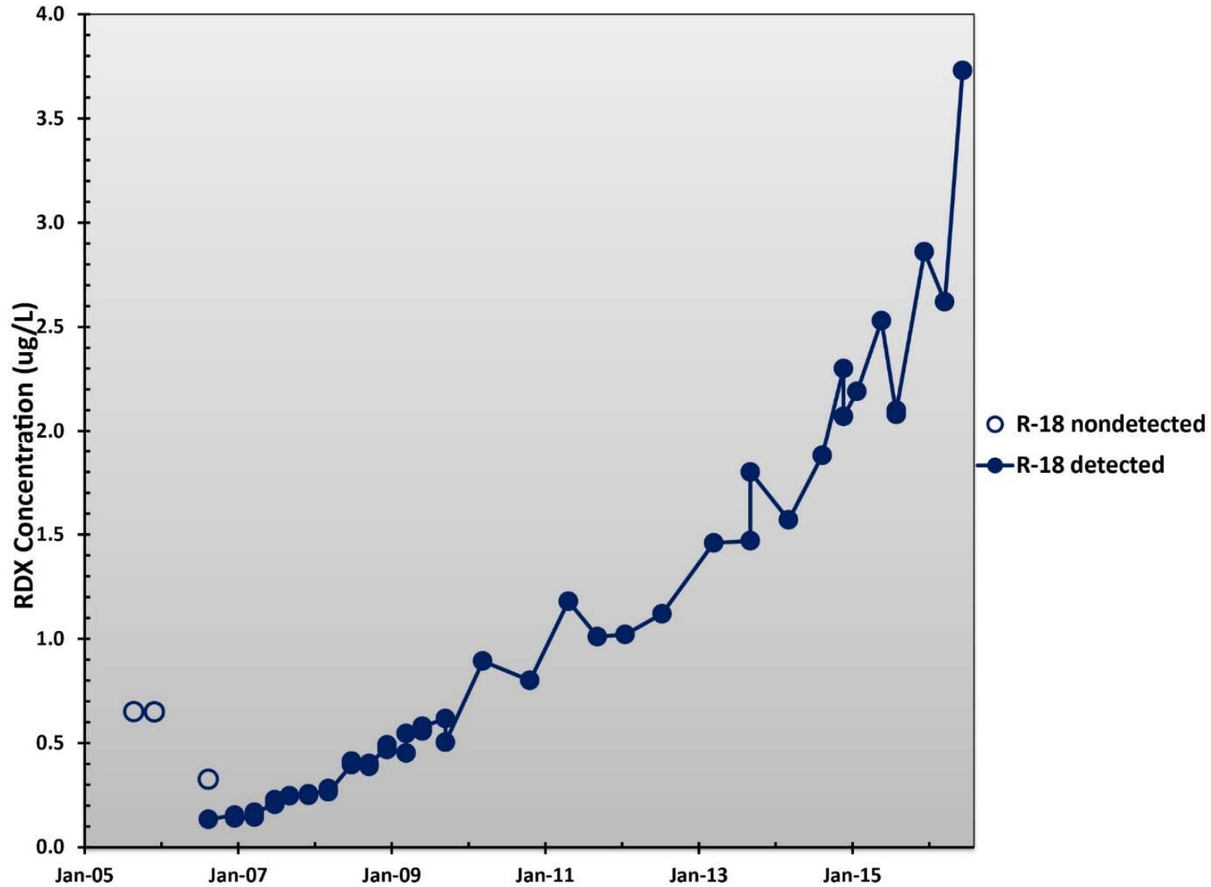


Figure 1.1-1 RDX concentrations in R-18, 2005 to present

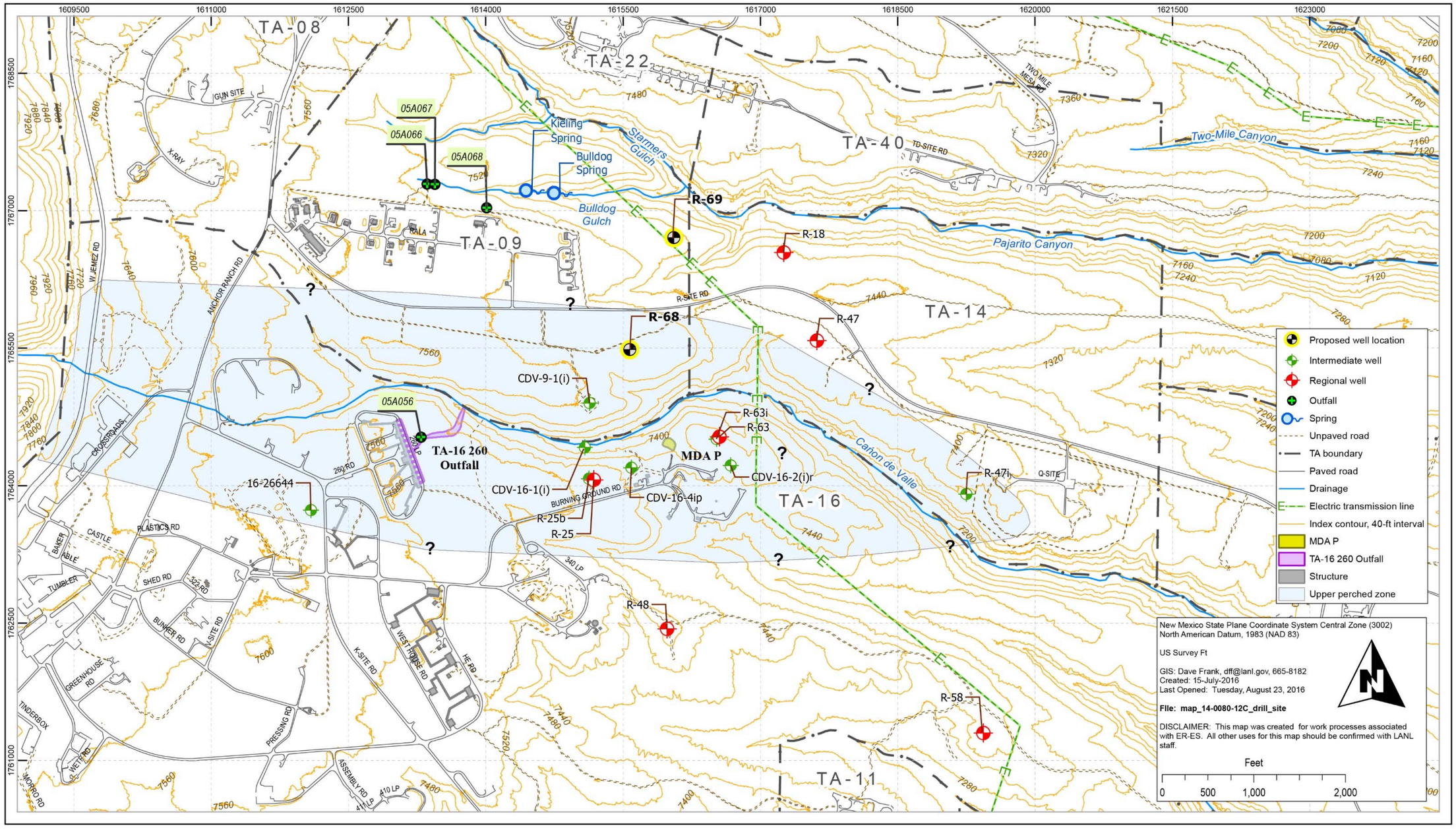


Figure 2.0-1 Proposed well locations north of Cañon de Valle

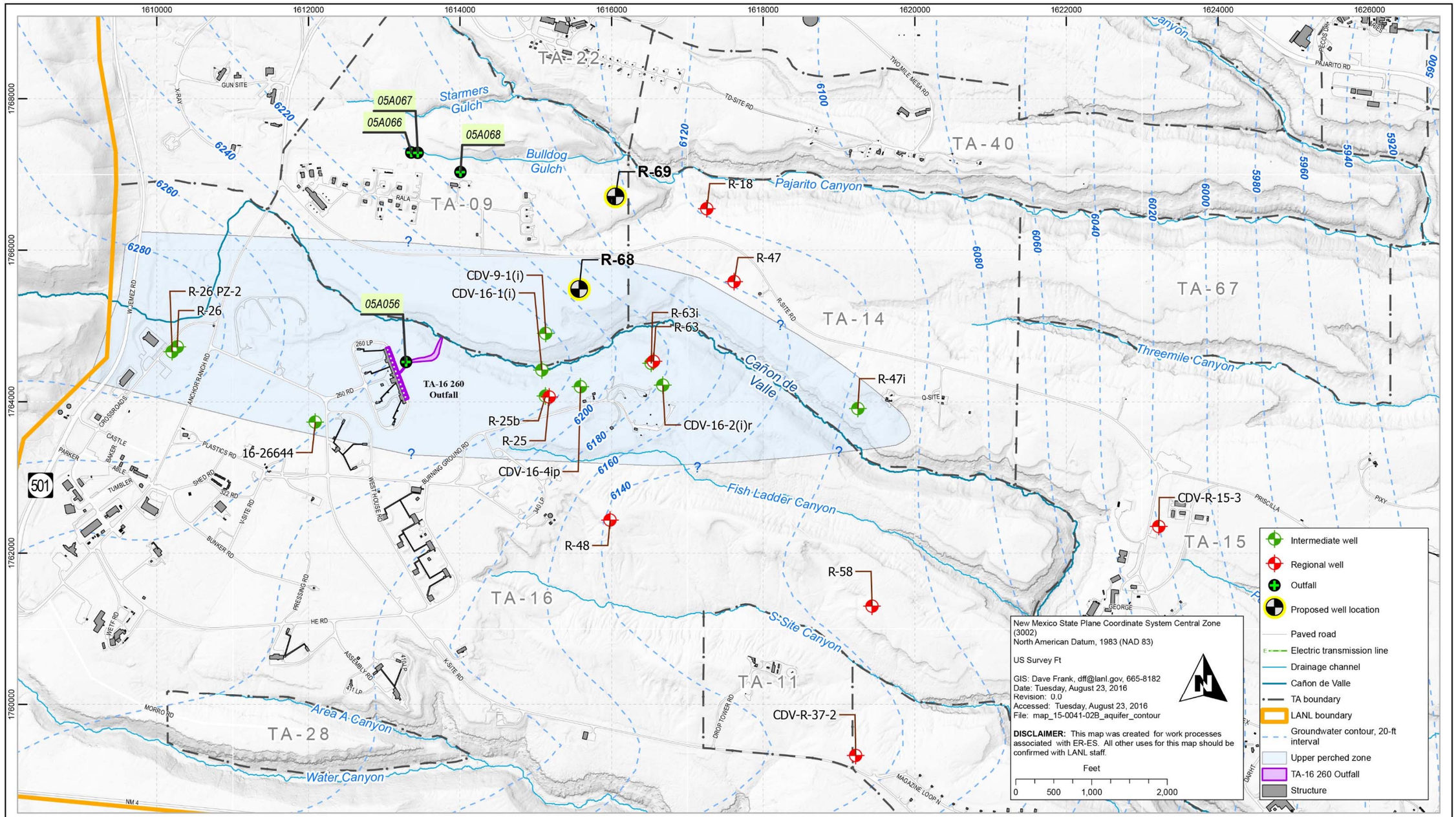


Figure 2.0-2 Water-table map for the regional aquifer in the area of TA-16 and TA-09, based on 2016 data

Appendix A

Drilling Work Plan for Well R-68

Drilling Work Plan for Well R-68

Primary Purpose	Proposed regional monitoring well R-68 will be located on the mesa north of Cañon de Valle, approximately 500 ft northeast of CdV-9-1(i), as shown on Figure 1. Installation of this well will help to address the objectives described in section 2 of the Groundwater Investigation Work Plan for Consolidated Unit 16-021(c)-99. The location for regional well R-68 was selected to address the potential contaminant flow path between Cañon de Valle and well R-18. Groundwater chemistry data from this well and from characterization within the vadose zone during drilling will help constrain the nature and extent of perched-intermediate groundwater and contamination in the regional aquifer associated with infiltration along Cañon de Valle. Water-level data from this well will also provide important information for the elevation of the regional water table and groundwater flow direction north of Cañon de Valle. The location for R-68 was selected in part to provide additional information on the nature and extent of the upper perched zone with elevated RDX (hexahydro-1,3,5-trinitro-1,3,5-triazine) detected at CdV-9-1(i). If perched groundwater is encountered, screening samples for high explosives (HE) will be collected during drilling. Lastly, the proposed location for R-68 should make it useful for long-term performance monitoring of any likely corrective measures that may be implemented to protect the regional aquifer. The depth to the top of the perched-intermediate zone of saturation at R-68 is not known but may be as shallow as 600 ft below ground surface (bgs), based on the current depth to the upper perched system at CdV-9-1(i). The target depth for the borehole is 1425 ft bgs, about 100 ft below the expected elevation at the top of the regional aquifer. The depth and occurrence of perched and regional groundwater are uncertain, and the target depth may be adjusted once the top of the regional aquifer is identified. Figure 2 shows the predicted geology, potential groundwater-producing intervals, and proposed well design for R-68. The well is tentatively designed with a single well screen to be placed near the top of the regional aquifer in Puye Formation deposits. Final selection of the well screen length and its position will be based on data obtained during drilling, including information from lithologic logs of cuttings, water-level measurements, video logs, geophysical logs, and drilling crew observations. A final well design will be based on hydrogeological conditions encountered during drilling, and a revised well design document will be submitted to the New Mexico Environment Department (NMED) for approval before well construction begins.
Conceptual Model	The conceptual model for the 260 Outfall area within Technical Area 16 (TA-16) is of a line-source recharge to the vadose zone forming a complex system of perched-intermediate zones present on both sides of an east-west trace of Cañon de Valle downstream from the former outfall location. The potential exists for zones of contaminated perched-intermediate groundwater, similar to those identified at CdV-9-1(i), to be present farther north of the canyon, possibly contributing to the RDX detected at regional aquifer well R-18. Installation of well R-68 will further refine the conceptual model and aid in identifying the source(s) of the RDX detected at R-18.

Drilling Approach	Drilling will be conducted with methods selected to optimize the potential of completing the well without using drilling additives in, or immediately above, the regional aquifer. A combination of open-hole and casing-advance methods will be employed. Each interval of open hole or casing advance will be optimized to meet the objectives. A down-the-hole (DTH) hammer, with or without casing advance, may be used to advance the borehole. If a DTH hammer is employed, hammer oil will be used as a lubricant down to a depth of 1225 ft (approximately 100 ft above the expected regional aquifer water table at this location). Below 1225 ft bgs, the DTH hammer without lubricating oil may be used. If this method is unsuccessful, a tricone bit air-rotary method will be used. Drilling foam may be used to condition the borehole, lift cuttings, and reduce the use of compressed air but will also be terminated at 1225 ft bgs. After the surface conductor casing is set, drilling will advance open hole targeting the top of the Puye Formation at approximately 789 ft bgs. If perched-intermediate groundwater is present, samples will be collected for RDX screening. If perched water is present within the Bandelier Tuff, a string of drill casing may be sealed in place before the borehole is advanced to prevent perched water from advancing downhole with drilling. Casing-advance methods will then be used through the deeper perched-intermediate zone that may be present within the Puye Formation. If perched saturation is present, screening samples for RDX, HE, tritium, cations/metals, and anions will be collected. Groundwater production will be estimated as each 20-ft section of drill casing is advanced. A screening sample will be airlifted at startup after each new joint connection. To reduce the risk of potentially contaminated perched groundwater entering the regional aquifer, a second string of drill casing will be landed approximately 100 ft above the regional aquifer and sealed in place.
Potential Drilling Fluids, Composition, and Use	Fluids and additives that may be used to facilitate drilling will be consistent with those previously used in the drilling program at Los Alamos National Laboratory (the Laboratory) and already characterized geochemically. Fluids and additives previously authorized for use by NMED include • potable municipal water supply to aid in the delivery of other drilling additives and cooling the drill bit; • QUIK-FOAM, a blend of alcohol ethoxy sulfates, used as a foaming agent; and • AQF-2, an anionic surfactant, used as a foaming agent. Complete records will be maintained detailing the type, amount, and volume of drilling fluid used, the depth at which drilling fluid is added to the borehole, the amount in storage in the borehole, and the recovery volume of drilling fluid. No drilling fluids, except potable municipal water, will be used within 100 ft of the perched-intermediate zone of saturation. If the target zone cannot be reached without the addition of drilling fluids, the situation will be discussed with NMED. No chemicals, other than those listed above, will be added without NMED's approval.
Potential Groundwater Occurrence and Detection	*Potential Perched Water:* Based on drilling observations at CdV-9-1(i), perched water is expected at this location. The predicted depths of groundwater are approximately 600–900 ft and 1060–1220 ft bgs. However, the depth and length of actual saturated sections are not known. *Regional:* The top of the regional aquifer is projected to occur at approximately 1325 ft bgs. Methods to detect perched groundwater may include driller's observations, water-level measurements, borehole video, borehole geophysics, and monitoring for pressure responses in nearby wells.
Core Sampling	To evaluate RDX retardation in the perched groundwater, up to 20 ft of continuous core may be collected.

Perched Groundwater Screening Sampling	Groundwater screening samples will be collected by airlifting within perched-intermediate groundwater zones as is reasonably feasible. The general approach involves airlifting to remove borehole (drilling) water and allowing formation water to enter the borehole. Airlifting is conducted again for sample collection. Resting the borehole following sampling will allow the static water level of perched zones to be estimated. The screening samples will be analyzed for cations/metals (dissolved and total) and anions (dissolved) by the Earth and Environmental Sciences (EES) Division's Geochemistry and Geomaterials Research Laboratory (GGRL) and for HE and tritium by off-site laboratories. Additionally, RDX screening samples will be collected every 20 ft while drilling through the deep-perched interval. These samples will be submitted to the EES Division's GGRL for analysis.
Regional Aquifer Groundwater Characterization Sampling	Groundwater samples will be collected from the completed well between 10 d and 60 d after well development in accordance with the Compliance Order on Consent. These samples will be analyzed for the full suite of constituents identified in the Interim Facility-Wide Groundwater Monitoring Plan for monitoring year 2017 for the TA-16 260 monitoring group.
Geophysical Testing	The Laboratory's borehole video camera, natural gamma, and induction tools will be used in the open borehole, if conditions allow. A full suite of geophysical logs will be run, if required, for proper placement of the screen. For open-hole conditions, the logs will include accelerator porosity sonde (neutron porosity), array induction, combined magnetic resonance, natural and spectral gamma, and formation microimager logs. In cased portions of the borehole, neutron porosity, triple lithodensity, elemental capture, natural gamma, and spectral gamma logs will be collected. These logs will be used to characterize the hydraulic properties of saturated rocks in the regional aquifer. The geophysical logs also will be used to select the well screen depths. The suite and timing of geophysical logging will depend on borehole conditions.
Well Completion Design	Figure 2 shows the conceptual well design and predicted geology for well R-68.
Well Development	The well may be developed by both mechanical and chemical means. Mechanical means include swabbing, bailing, and pumping. Chemical means include the use of additives to remove clays and/or chlorination to kill bacteria introduced during well completion. • After initial swabbing and bailing, a submersible pump will be used to complete the development process. • Water-quality parameters will be measured in a flow-through cell. The parameters to be monitored are pH, specific conductance, dissolved oxygen, temperature, turbidity, oxidation-reduction potential, and total organic carbon (TOC). • If the Laboratory is unable to bring the water-quality parameters to within the limits specified below, the use of chemical well development may be discussed with NMED. No chemicals will be added without NMED's approval. Chemical means that may be used include sodium acid pyrophosphate and AQUACLEAR PFD to remove clays and/or chlorination. Well development will be considered complete when target water-quality parameters are met and a volume of water equivalent to that which was introduced into the aquifer during drilling and construction is removed. The target water-quality parameters are turbidity <5 nephelometric turbidity units, TOC <2 ppm, and other parameters stable.

Hydraulic Testing	A 24-h constant-rate pumping test will be conducted following well development.
Investigation-Derived Waste Management	Investigation-derived waste (IDW) will be managed in accordance with the requirements in P-409, Waste Management, and EP-DIR-SOP-10021, Characterization and Management of Environmental Programs Waste, available at http://www.lanl.gov/environment/plans-procedures.php. This standard operating procedure incorporates the requirements of applicable U.S. Environmental Protection Agency and NMED regulations, U.S. Department of Energy orders, and Laboratory requirements. The primary waste streams include drill cuttings, drilling water, development water, purge water, decontamination water, and contact waste. Drill cuttings will be managed in accordance with the NMED-approved Decision Tree for the Land Application of Drill Cuttings (April 2016). Drilling, purge, and development waters will be managed in accordance with the NMED-approved Notice of Intent Decision Tree for Drilling, Development, Rehabilitation, and Sampling Purge Water (March 2010). Initially, drill cuttings and drilling water will be stored in lined pits. The cuttings may or may not contain residue of drilling/well completion additives (e.g., drilling foam and bentonite clay). The contents of the pits will be characterized with direct sampling following completion of drilling activities, and waste determinations will be made from validated data. If validated analytical data show these wastes cannot be land-applied, they will be removed from the pit, containerized, and placed in accumulation areas appropriate to the type of waste. Cuttings, drilling water, development water, and purge water that cannot be land-applied and are designated as hazardous waste will be sent to an authorized treatment, storage, or disposal facility within 90 d of containerization. Development water, purge water, and decontamination water will be containerized separately at their point of generation, placed in an accumulation area appropriate to the type of waste, and directly sampled. Contact waste will be containerized at the point of generation, placed in an appropriate accumulation area, and characterized using acceptable knowledge of the media with which it came in contact.
Schedule	Well R-68 will be completed and sampled by February 28, 2017. Additional details of the schedule are presented in “Groundwater Investigation Work Plan for Consolidated Unit 16-021(c)-99, Including Drilling Work Plans for Wells R-68 and R-69.” Monitoring conducted after R-68 is installed will be implemented under the Interim Facility-Wide Groundwater Monitoring Plan.

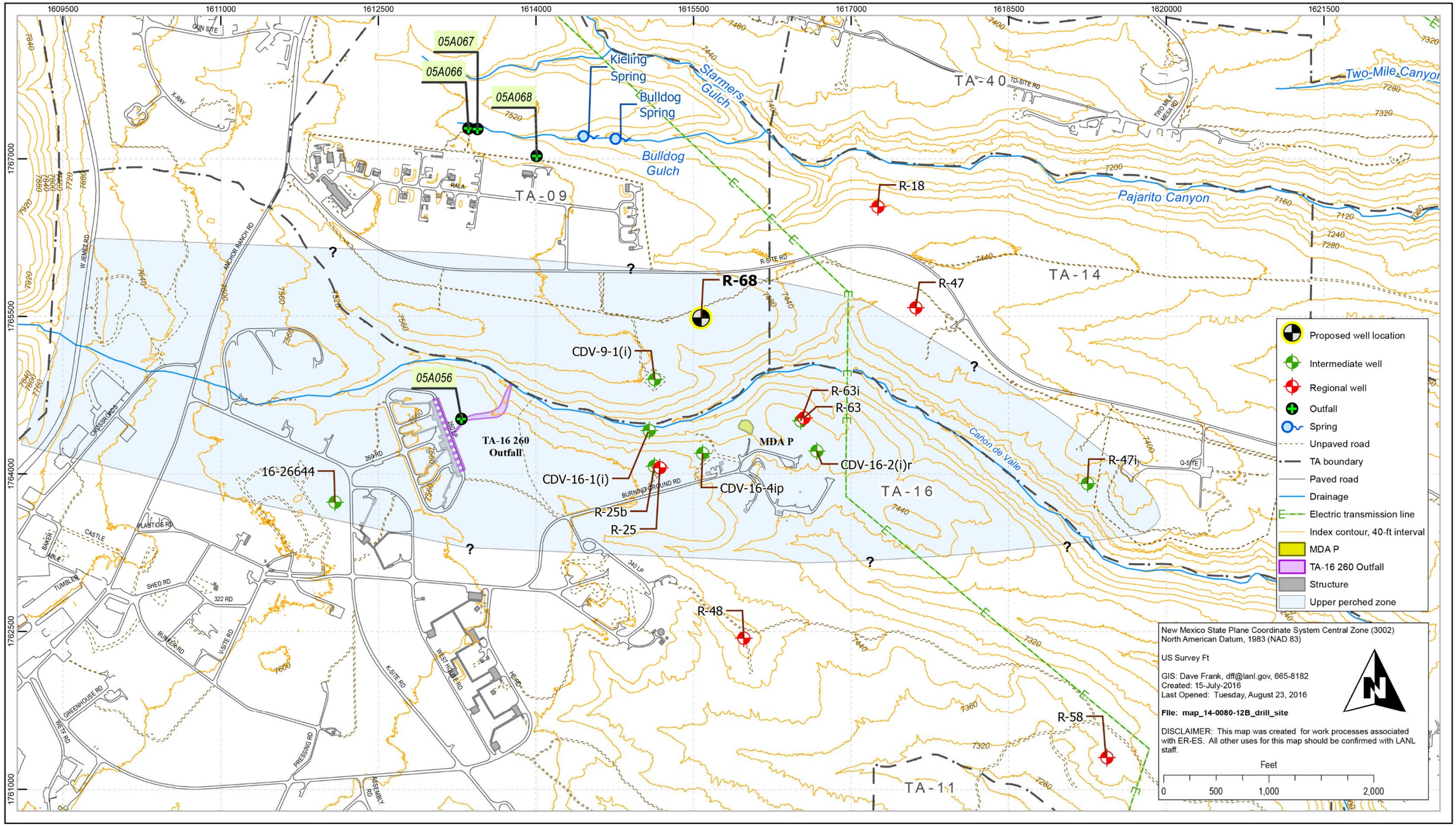
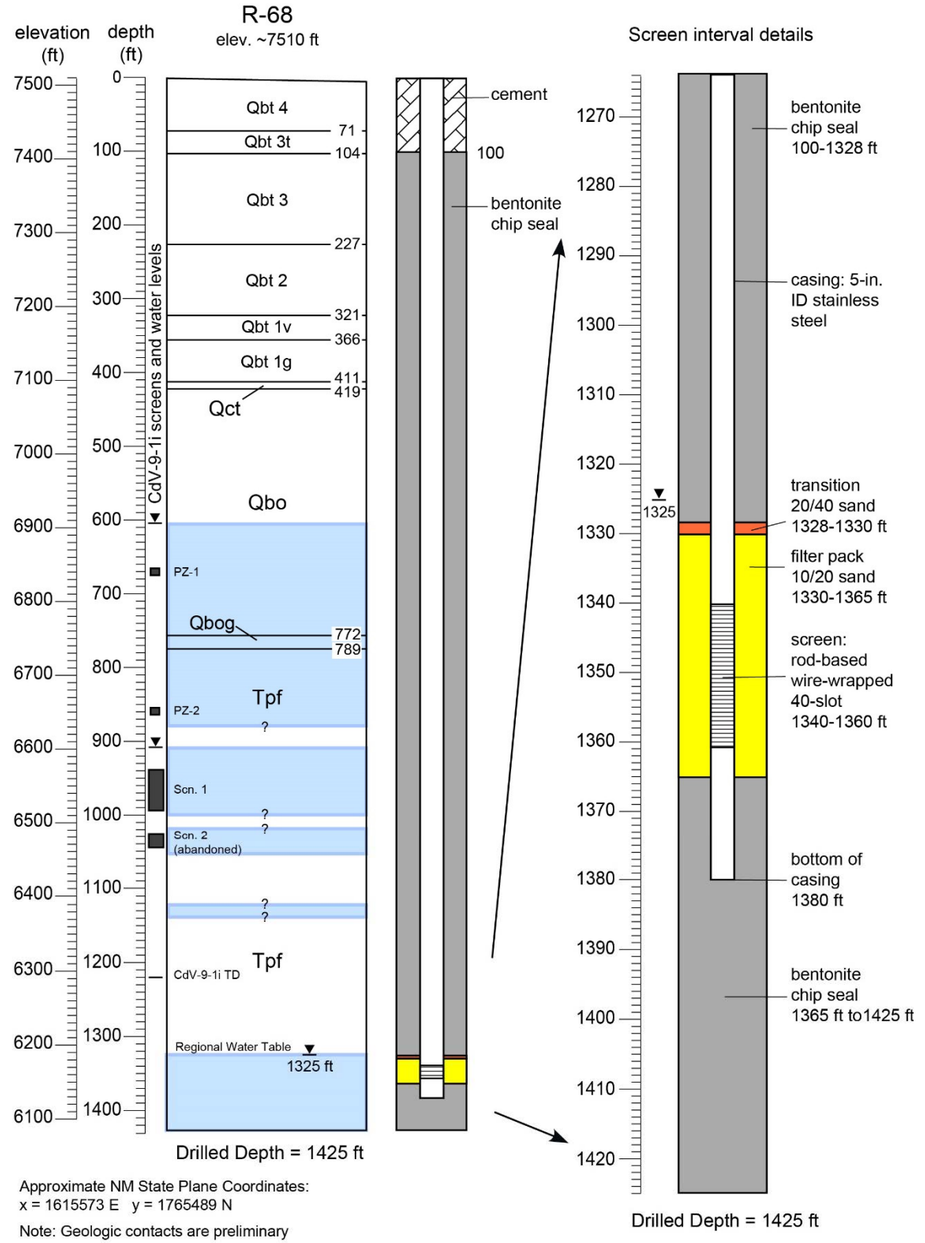


Figure 1 Proposed location of well R-68



Note: Screen placement will be determined based on depths of saturation observed during drilling

Figure 2 Predicted geology and proposed well design for well R-68

Appendix B

Drilling Work Plan for Well R-69

Drilling Work Plan for Well R-69

Primary Purpose	Proposed regional monitoring well R-69 will be located north of Cañon de Valle and east of Technical Area 09 (TA-09) on the mesa south of Bulldog Gulch (Figure 1). The proposed location will be approximately 1250 ft west of R-18. Installation of R-69 will help to address work plan objectives described in section 2 of the Groundwater Investigation Work Plan for Consolidated Unit 16-021(c)-99. The location for regional well R-69 was selected because of its relative proximity to TA-09, Bulldog Gulch, and the confluence of Bulldog Gulch and Pajarito Canyon. This location was selected specifically to address the potential for a TA-09 source for high explosives (HE) contamination in well R-18. Well R-69 will also provide data regarding contaminant concentrations at the top of the regional aquifer in the vicinity of TA-09, downgradient of the TA-09 outfalls in Bulldog Gulch. Water-level data from this well will be used to constrain the regional water table and groundwater flow direction in this area and may help to determine the source of contamination at R-18 based on groundwater flow direction. Data from R-69 will also provide information on the nature of perched-intermediate groundwater in the area. If perched-intermediate groundwater is encountered, screening samples for high explosives (HE) will be collected during drilling. Given R-69's proximity to TA-09, screening data collected during drilling may provide useful information regarding potential sources of HE contamination in the area and the lateral extent of the RDX- (hexahydro-1,3,5-trinitro-1,3,5-triazine–) contaminated perched zones north of Cañon de Valle at CdV-9-1(i). It is not known whether perched-intermediate groundwater will be present at R-69. Although it was not encountered during drilling at R-18, approximately 1250 ft to the east, perched water has been encountered within the Cerro Toledo interval, the base of the Otowi Member of the Bandelier Tuff (including the Guaje Pumice Bed), and above low-permeability beds within the Puye Formation. The drilling crew will monitor for evidence of saturation at each of these zones during drilling. The target depth for the borehole is 1395 ft below ground surface (bgs), about 100 ft bgs within the regional aquifer. The depth of the regional groundwater is uncertain, and the target depth may be adjusted once the top of the regional aquifer is identified. Figure 2 shows the predicted geology, expected groundwater-producing interval, and proposed well design for R-69. The well is tentatively designed with a single well screen to be placed near the top of the regional aquifer in Puye Formation deposits. Final selection of the well screen length and position will be based on data obtained during drilling, including information from lithologic logs of cuttings, water-level measurements, video logs, geophysical logs, and drilling crew observations. A final well design will be based on hydrogeological conditions encountered during drilling, and a revised well design document will be submitted to the New Mexico Environment Department (NMED) for approval before well construction begins.
Conceptual Model	The conceptual model for the TA-09 outfall area is of a line-source recharge to the subsurface along the east-west trace of Bulldog Gulch downstream from the outfalls. The potential exists for zones of contaminated perched-intermediate groundwater, similar to those identified at CdV-9-1(i), to be present, possibly contributing to the RDX detected at regional aquifer well R-18. If necessary, R-69 will be used to further refine the conceptual model and aid in identifying the source(s) of the RDX, and other HE and HE-degradation products detected at R-18.

Drilling Approach	Drilling will be conducted with methods selected to optimize the potential of completing the well without using drilling additives in, or immediately above, the regional aquifer. A combination of open-hole and casing-advance methods will be employed. Each interval of open hole or casing advance will be optimized to meet the objectives. A down-the-hole (DTH) hammer, with or without casing advance, may be used to advance the borehole. If a DTH hammer is employed, hammer oil will be used as a lubricant down to a depth of 1195 ft bgs, approximately 100 ft above the expected top of the regional aquifer water table at this location. Below 1195 ft bgs, the DTH hammer without lubricating oil may be used. If this method is unsuccessful, a tricone bit air-rotary method will be used. Drilling foam may be used to condition the borehole, lift cuttings, and reduce the use of compressed air but will also be terminated at 1195 ft bgs. After the surface conductor casing is set, drilling will advance open hole, targeting the top of the Puye Formation at approximately 669 ft bgs. If perched-intermediate groundwater is present, samples will be collected for RDX screening, and a string of drill casing may be sealed in place before the borehole is advanced to prevent perched water from advancing downhole with drilling. Casing-advance methods may then be used through the same deeper perched-intermediate zone within the Puye Formation that was observed at CdV-9-1(i) to the south. If perched saturation is present, screening samples for RDX, HE, tritium, cations/metals, and anions will be collected. Groundwater production will be estimated as each 20-ft section of drill casing is advanced. A screening sample will be airlifted at startup after each new joint connection. To reduce the risk of potentially contaminated perched groundwater entering the regional aquifer, a second string of drill casing will be landed approximately 100 ft above the regional aquifer and sealed in place if perched groundwater is observed.
Potential Drilling Fluids, Composition, and Use	Fluids and additives that may be used to facilitate drilling will be consistent with those previously used in the drilling program at Los Alamos National Laboratory (the Laboratory) and already characterized geochemically. Fluids and additives previously authorized for use by NMED include • potable municipal water supply to aid in the delivery of other drilling additives and cooling the drill bit; • QUIK-FOAM, a blend of alcohol ethoxy sulfates, used as a foaming agent; and • AQF-2, an anionic surfactant, used as a foaming agent. Complete records will be maintained detailing the type, amount, and volume of drilling fluid used, the depth at which drilling fluid is added to the borehole, the amount in storage in the borehole, and the recovery volume of drilling fluid. No drilling fluids, except potable municipal water, will be used within 100 ft of the perched-intermediate zone of saturation. If the target zone cannot be reached without the addition of drilling fluids, the situation will be discussed with NMED. No chemicals, other than those listed above, will be added without NMED's approval.
Potential Groundwater Occurrence and Detection	*Potential Perched Water:* Based on drilling observations at wells in the area, perched water is possible within the Cerro Toledo interval, at the base of the Otowi Member, and within the Puye Formation. The possible depths of groundwater are approximately 308–360 ft, 630–669 ft, and 700–1200 ft bgs. However, the depth and length of actual saturated sections, if present, are unknown. *Regional:* The top of the regional aquifer is projected to occur at approximately 1295 ft bgs. Methods to detect perched groundwater may include driller's observations, water-level measurements, borehole video, borehole geophysics, and monitoring for pressure responses in nearby wells.

Core Sampling	No core collection is planned.
Perched Groundwater Screening Sampling	Groundwater screening samples will be collected by airlifting within perched-intermediate groundwater zones as is reasonably feasible. The general approach involves airlifting to remove borehole (drilling) water and allowing formation water to enter the borehole. Airlifting is conducted again for sample collection. Resting the borehole following sampling will allow for estimations of the static water level of perched zones. The screening samples will be analyzed for cations/metals (dissolved and total), anions (dissolved), and RDX by the Earth and Environmental Sciences (EES) Division's Geochemistry and Geomaterials Research Laboratory (GGRL) and for HE and tritium by off-site laboratories. Additionally, RDX screening samples will be collected every 20 ft while drilling through the deep-perched interval. These samples will be submitted to the EES Division's GGRL for analysis.
Regional Aquifer Groundwater Characterization Sampling	Groundwater samples will be collected from the completed well between 10 d and 60 d after well development in accordance with the Compliance Order on Consent. These samples will be analyzed for the full suite of constituents identified in the Interim Facility-Wide Groundwater Monitoring Plan for monitoring year 2017 for the TA-16 260 monitoring group.
Geophysical Testing	The Laboratory's borehole video camera, natural gamma, and induction tools will be used in the open borehole if conditions allow. A full suite of geophysical logs will be run, if required, for proper placement of the screen. For open-hole conditions, the logs will include accelerator porosity sonde (neutron porosity), array induction, combined magnetic resonance, natural and spectral gamma, and formation microimager logs. In cased portions of the borehole, neutron porosity, triple lithodensity, elemental capture, natural gamma, and spectral gamma logs will be collected. These logs will be used to characterize the hydraulic properties of saturated rocks in the regional aquifer. The geophysical logs also will be used to select the well screen depths. The suite and timing of geophysical logging will depend on borehole conditions.
Well Completion Design	Figure 2 shows the conceptual well design and predicted geology for well R-69.
Well Development	The well may be developed by both mechanical and chemical means. Mechanical means include swabbing, bailing, and pumping. Chemical means include the use of additives to remove clays and/or chlorination to kill bacteria introduced during well completion. • After initial swabbing and bailing, a submersible pump will be used to complete the development process. • Water-quality parameters will be measured in a flow-through cell. The parameters to be monitored are pH, specific conductance, dissolved oxygen, temperature, turbidity, oxidation-reduction potential, and total organic carbon (TOC). • If the Laboratory is unable to bring the water-quality parameters to within the limits specified below, the use of chemical well development may be discussed with NMED. No chemicals will be added without NMED's approval. Chemical means that may be used include sodium acid pyrophosphate and AQUACLEAR PFD to remove clays and/or chlorination. Well development will be considered complete when target water-quality parameters are met and a volume of water equivalent to that which was introduced into the aquifer during drilling and construction is removed. The target water-quality parameters are turbidity <5 nephelometric turbidity units, TOC <2 ppm, and other parameters stable.

Hydraulic Testing	A 24-h constant-rate pumping test will be conducted following development.
Investigation-Derived Waste Management	Investigation-derived waste (IDW) will be managed in accordance with the requirements in P-409, Waste Management, and EP-DIR-SOP-10021, Characterization and Management of Environmental Programs Waste, available at http://www.lanl.gov/environment/plans-procedures.php. This standard operating procedure incorporates the requirements of applicable U.S. Environmental Protection Agency and NMED regulations, U.S. Department of Energy orders, and Laboratory requirements. The primary waste streams include drill cuttings, drilling water, development water, purge water, decontamination water, and contact waste. Drill cuttings will be managed in accordance with the NMED-approved Decision Tree for the Land Application of Drill Cuttings (April 2016). Drilling, purge, and development waters will be managed in accordance with the NMED-approved Notice of Intent Decision Tree for Drilling, Development, Rehabilitation, and Sampling Purge Water (March 2010). Initially, drill cuttings and drilling water will be stored in lined pits. The cuttings may or may not contain residue of drilling/well completion additives (e.g., drilling foam and bentonite clay). The contents of the pits will be characterized with direct sampling following completion of drilling activities, and waste determinations will be made from validated data. If validated analytical data show these wastes cannot be land-applied, they will be removed from the pit, containerized, and placed in accumulation areas appropriate to the type of waste. Cuttings, drilling water, development water, and purge water that cannot be land-applied and are designated as hazardous waste will be sent to an authorized treatment, storage, or disposal facility within 90 d of containerization. Development water, purge water, and decontamination water will be containerized separately at their point of generation, placed in an accumulation area appropriate to the type of waste, and directly sampled. Contact waste will be containerized at the point of generation, placed in an appropriate accumulation area, and characterized using acceptable knowledge of the media with which it came in contact.
Schedule	The need for well R-69 will be predicated on the results of groundwater sampling at R-68. The goal is to complete and collect the first sample from R-68 before February 28, 2017. A second sample would be collected in the May 2017 time frame. Quick-turnaround analysis will be requested for the samples, so a recommendation can be made to NMED regarding R-69 by June 30, 2017. If drilling R-69 is necessary to fulfill the objectives of the “Groundwater Investigation Work Plan for Consolidated Unit 16-021(c)-99, Including Drilling Work Plans for Wells R-68 and R-69,” a specific completion date will be proposed at that time. Monitoring conducted after R-69 is installed will be implemented under the Interim Facility-Wide Groundwater Monitoring Plan.

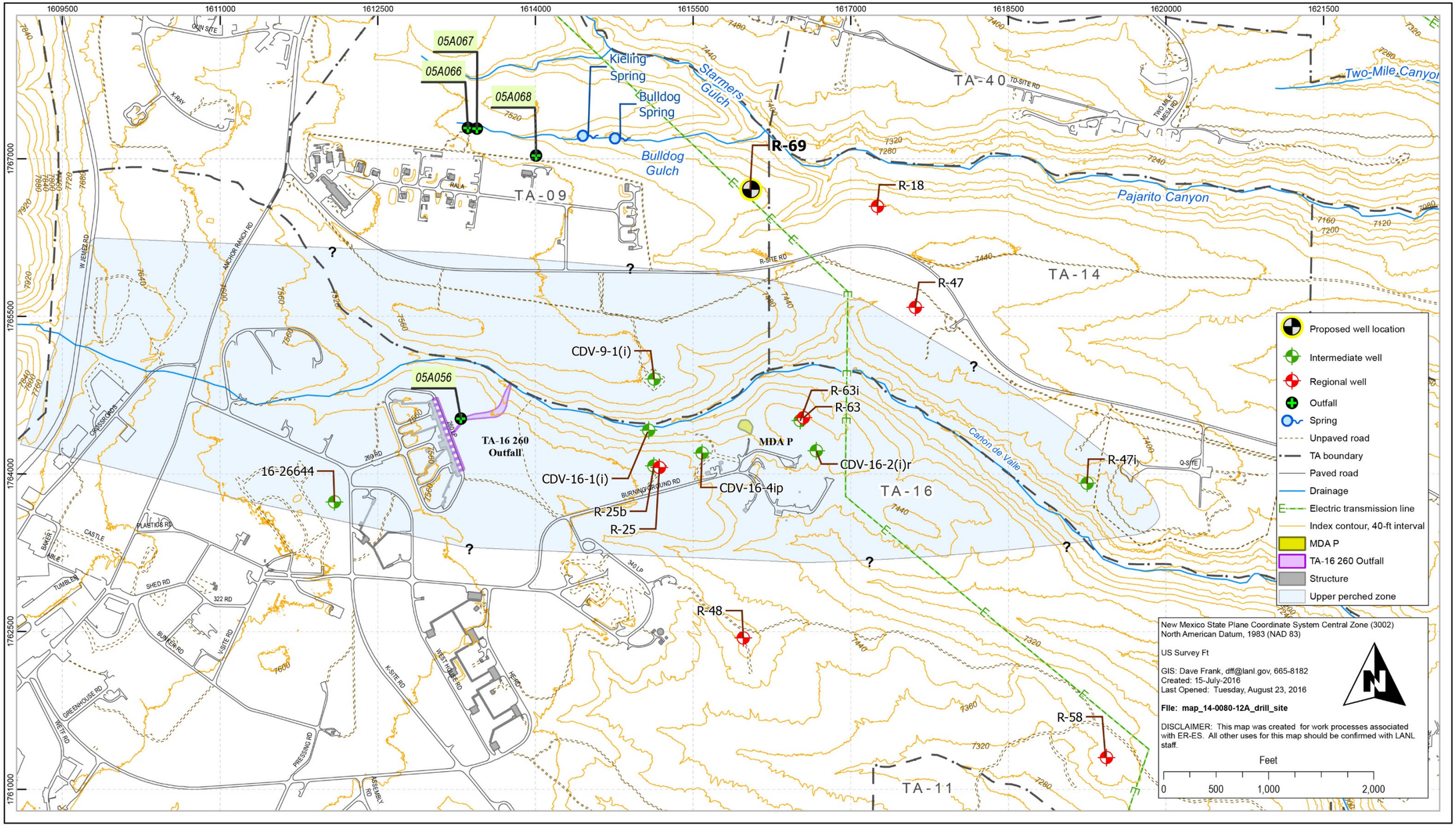
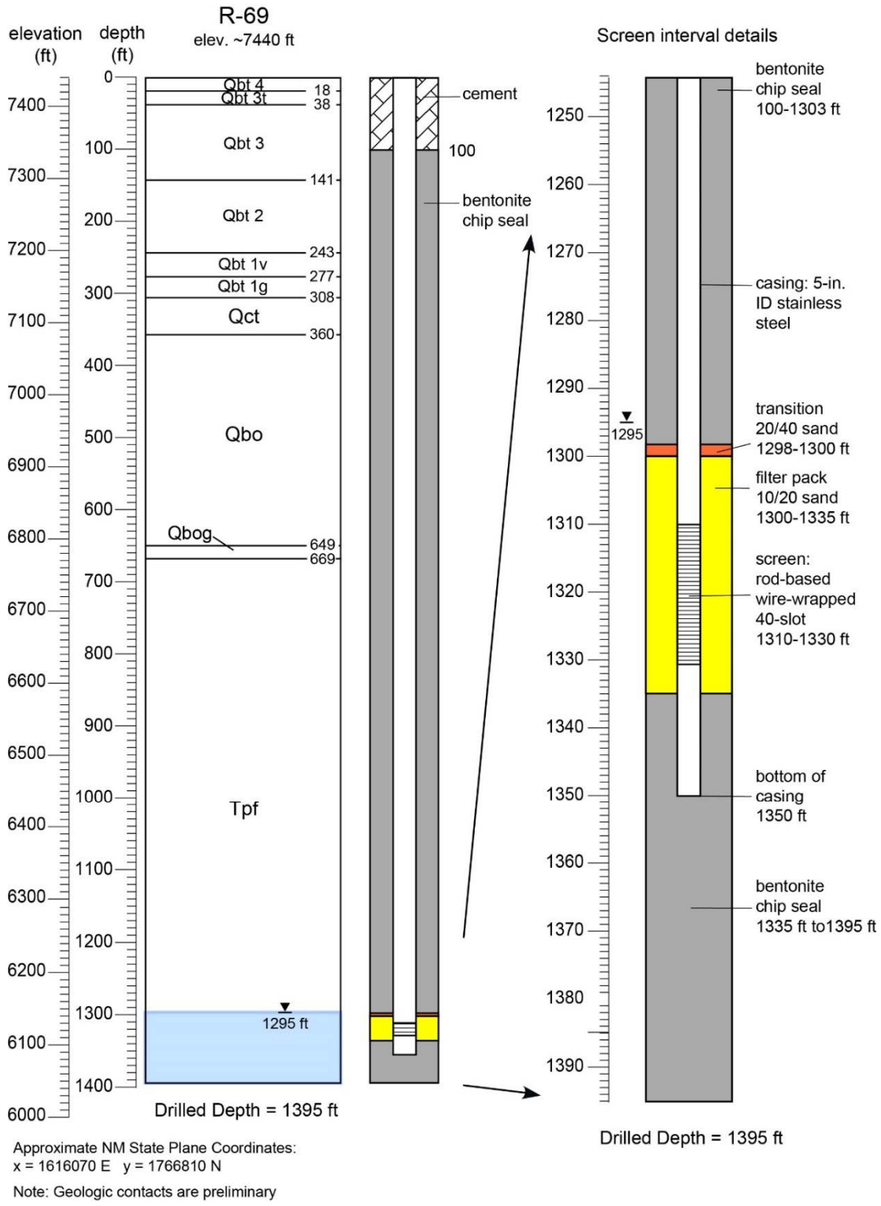


Figure 1 Proposed location of well R-69



Note: Screen placement will be determined based on depths of saturation observed during drilling.

Figure 2 Predicted geology and proposed well design for well R-69