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

Subject: Annual Progress Report for Corrective Measures Evaluation/Corrective Measures Implementation for Consolidated Unit 16-021(c)-99

Dear Mr. Kieling:

Enclosed please find two hard copies with electronic files of the Annual Progress Report for Corrective Measures Evaluation/Corrective Measures Implementation for Consolidated Unit 16-021(c)-99. This report summarizes activities Los Alamos National Laboratory completed from October 2015 to September 2016 related to the corrective measures evaluation/corrective measures implementation for Consolidated Unit 16-021(c)-99, the Technical Area 16 260 Outfall.

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
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BR/DR/SS:sm

Enclosures: Two hard copies with electronic files – Annual Progress Report for Corrective Measures Evaluation/Corrective Measures Implementation for Consolidated Unit 16-021(c)-99 (EP2016-0143)

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LA-UR-16-28862
November 2016
EP2016-0143

Annual Progress Report for Corrective Measures Evaluation/Corrective Measures Implementation for Consolidated Unit 16-021(c)-99

Los Alamos
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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.

EP2016-0143

Annual Progress Report for Corrective Measures Evaluation/ Corrective Measures Implementation for Consolidated Unit 16-021(c)-99

November 2016

Responsible project manager:

Printed Name	Signature	Title	Organization	Date
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Responsible LANS representative:

Printed Name	Signature	Title	Organization	Date
Randall Erickson	R Erickson	Associate Director	Associate Directorate for Environmental Management	11/17/16

Responsible DOE-EM-LA representative:

Printed Name	Signature	Title	Organization	Date
David S. Rhodes	David S. Rhodes	Office Director	Quality and Regulatory Compliance	11-22-2016

EXECUTIVE SUMMARY

Significant achievements accomplished during the fiscal year 2016 reporting period include submitting the R-58 well completion report; conducting quarterly groundwater sampling; deploying groundwater tracers in select wells and conducting five rounds of tracer breakthrough sampling; implementing extended cross-borehole aquifer tests in three perched-intermediate wells; submitting the "Groundwater Investigation Work Plan for Consolidated Unit 16-021(c)-99, Including Drilling Work Plans for Wells R-68 and R-69"; submitting an evaluation report for surface corrective measures implementation closure at Consolidated Unit 16-021(c)-99; completing a comprehensive review of the geology of Technical Area 16 and vicinity; and continuing studies of the geochemistry, geohydrology, and the potential for natural attenuation and bioremediation.

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1.0 INTRODUCTION

This report serves as the first annual progress report for the corrective measures evaluation/corrective measures implementation (CME/CMI) for Consolidated Unit 16-021(c)-99. It summarizes activities Los Alamos National Laboratory (LANL or Laboratory) completed from October 2015 to September 2016 related to the CME/CMI for Consolidated Unit 16-021(c)-99, the Technical Area 16 (TA-16) 260 Outfall.

The most recent progress reports on the CME/CMI for Consolidated Unit 16-021(c)-99 were submitted semiannually; however, in the New Mexico Environment Department's (NMED's) "Approval with Modifications, Semiannual Progress Report for Corrective Measures Evaluation/Corrective Measures Implementation for Consolidated Unit 16-021(c)-99" (NMED 2016, 601213), NMED approved decreasing the reporting period for progress reports from semiannually to annually, to be submitted on November 30 of each year.

The U.S. Department of Energy (DOE) and Los Alamos National Security, LLC (LANS) submitted the "Corrective Measures Evaluation Report, Intermediate and Regional Groundwater, Consolidated Unit 16-021(c)-99" (hereafter, the CME report) in August 2007 (LANL 2007, 098734). NMED issued a notice of disapproval (NOD) in April 2008 (NMED 2008, 101311), requesting additional characterization to evaluate the feasibility of the remedial alternatives proposed in the groundwater CME and to assess the extent of contamination in perched-intermediate groundwater and in the regional aquifer.

This progress report summarizes activities conducted to address data gaps identified in NMED's NOD on the CME report. It also includes activities related to the surface CMI implemented in 2009 and 2010 to remediate high explosives (HE) and other contaminants at the 260 Outfall, and in the alluvial systems of Cañon de Valle and Martin Spring Canyon (LANL 2007, 098192; LANL 2010, 108868; LANL 2010, 111508).

2.0 SURFACE CMI

2.1 Best Management Practices

Inspection of best management practices (BMPs) associated with Consolidated Unit 16-021(c)-99 is completed under the Individual Storm Water Permit, pursuant to the requirements of National Pollutant Discharge Elimination System Permit No. NM0030759 (hereafter, the Individual Permit), as authorized by the U.S. Environmental Protection Agency (EPA). Current BMPs, called controls in the Individual Permit, include a low-permeability cap consisting of a 20-in.-thick crushed tuff/bentonite cap installed on top of the former settling pond, five earthen berms and one rock check dam installed to control run-on/runoff, riprap within the former channel to control runoff, and established vegetation to control erosion from the site. Controls are inspected annually and following a significant rain event of 0.25 in. or greater within 30 min, as measured at rain gage RG257, per the Individual Permit.

During the period from October 1, 2015, to September 30, 2016, the following significant rain events were recorded at rain gage RG257:

Date	30-min Maximum Intensity	24-h Total	BMP Inspection Date	BMP Maintenance Date
06/01/2016	0.25	0.26	06/10/2016	—*
07/01/2016	0.26	0.28	07/08/2016	—
07/28/2016	0.26	0.26	07/29/2016	—
08/03/2016	0.32	0.45	08/09/2016	—
08/24/2016	0.44	0.80	08/26/2016	—
09/05/2016	0.25	0.40	09/09/16	—

*— = No maintenance required.

Per the Individual Permit, if several storms exceeding the intensity threshold of 0.25 in. in 30 min occur over a period not to exceed 15 d from the first event, a single inspection is sufficient to achieve compliance (hence the number of events may differ from the number of inspections). Inspection results will be reported in the "Storm Water Individual Permit Annual Report, Reporting Period: January 1–December 31, 2016" and submitted to the EPA Region 6 Enforcement Division as well as to the NMED Surface Water Quality Bureau (NMED-SWQB).

2.2 Hydrogeologic Investigations

Routine groundwater and surface water monitoring at TA-16 260 monitoring group locations was conducted in accordance with the "Interim Facility-Wide Groundwater Monitoring Plan for the 2016 Monitoring Year, October 2015–September 2016" (the Interim Plan) (LANL 2015, 600467) . Groundwater sampling events were conducted in December 2015, March 2016, May–June 2016, and September 2016. Data from the December 2015 and March 2016 sampling events were included in the August 31, 2016, periodic monitoring report for the TA-16 260 monitoring group (LANL 2016, 601742). Data from the May–June 2016 and September 2016 sampling events will be included in the periodic monitoring report for the TA-16 260 monitoring group, to be submitted August 31, 2017.

The December 2015 first quarter sampling event was conducted from December 1 to December 14, 2015. Samples were collected from three base-flow locations, two springs, five alluvial monitoring wells, five monitoring wells completed in the perched-intermediate groundwater, and two regional monitoring wells. Alluvial monitoring well FLC-16-25280 was not sampled because of insufficient water. Perched-intermediate groundwater monitoring well CdV-9-1(i) was not sampled because groundwater tracers had been recently introduced into this well. Monitoring well R-58 was not sampled because a sampling system had not yet been installed in the well.

The March 2016 second quarter sampling event was conducted from March 14 to March 30, 2016. Samples were collected from three base-flow locations, four springs, five alluvial monitoring wells, nine monitoring wells completed in the perched-intermediate groundwater, and six regional monitoring wells. Alluvial monitoring well FLC-16-25280 was not sampled because of insufficient water. Perched-intermediate groundwater monitoring well R-47i was not sampled because the well was inaccessible as a result of restrictions in place protecting threatened and endangered species. Regional monitoring well CdV-R-37-2 screen 2 was not sampled because of problems with the pump.

The May–June 2016 third quarter sampling event was conducted from May 26 to June 23, 2016. Samples were collected from three base-flow locations, two springs, four alluvial monitoring wells, six monitoring wells completed in the perched-intermediate groundwater, and three regional monitoring wells. Alluvial monitoring wells FLC-16-25280 and MSC-16-06293 were not sampled because of insufficient water.

The September 2016 fourth quarter sampling event was conducted from September 9 to September 22, 2016. Samples were collected from two base-flow locations, four springs, four alluvial monitoring wells, five monitoring wells completed in the perched-intermediate groundwater, and seven regional monitoring wells. Baseflow location Water at Beta was not sampled because of access restrictions. Alluvial monitoring wells FLC-16-25280 and MSC-16-06293 were not sampled because of insufficient water. Perched-intermediate groundwater monitoring wells CdV-9-1(i), CdV-16-1(i), CdV-16-2-(i)r, and R-25b were not sampled because of the ongoing aquifer test activities at TA-16. Perched-intermediate groundwater monitoring well CdV-37-1(i) was not sampled because of access restrictions.

2.3 CMI Activities: October 2015 to September 2016

An "Evaluation Report for Surface Corrective Measures Implementation Closure, Consolidated Unit 16-021(c)-99" was submitted to the NMED on September 29, 2016 (LANL 2016, 601837), and approved by NMED on October 21, 2016 (NMED 2016, 601914). The evaluation report was developed in response to NMED's approval with modifications for the "Semiannual Progress Report for Corrective Measures Evaluation/Corrective Measures Implementation for Consolidated Unit 16-021(c)-99" (NMED 2016, 601213). The approval directed the Laboratory to submit an evaluation report to NMED by September 30, 2016, addressing current issues relevant to the CMI, including (1) removal or reclamation of the permeable reactive barrier (PRB); (2) the adequacy of the alluvial groundwater well network; and (3) the potential for using carbon-filtration treatment systems at Burning Ground, Sanitary Wastewater Systems Consolidation (SWSC), and Martin Springs.

The evaluation report also included plans for plugging and abandonment of PRB alluvial monitoring wells, removal of Cañon de Valle PRB debris, and installation of one additional alluvial monitoring well in Cañon de Valle. Furthermore, it recommended that no treatment was necessary at SWSC, Burning Ground, and Martin Springs based on long-term declining trends in RDX (hexahydro-1,3,5-trinitro-1,3,5-triazine) concentrations in downgradient alluvial groundwater. Following completion of the proposed activities in the evaluation report, a surface CMI closure report for Consolidated Unit 16-021(c)-99 will be prepared documenting completion of all CMI activities.

3.0 SUBSURFACE CME

3.1 CME for Deep Groundwater

DOE and LANS submitted the CME report in August 2007 and recommended a remediation strategy of monitored natural attenuation for the intermediate and regional groundwater, with possible pump and treat to reduce HE contaminant concentrations in groundwater (LANL 2007, 098734). NMED subsequently issued an NOD for the CME report in April 2008 (NMED 2008, 101311). In the NOD, NMED required the Laboratory to conduct additional characterization to evaluate the feasibility of the remedial alternatives presented in the CME and to assess the extent of groundwater contamination in perched-intermediate groundwater and in the regional aquifer.

During the fiscal year (FY) 2016 reporting period, numerous activities were conducted to fill data gaps recognized from the original CME report (LANL 2007, 098734) and included completing regional monitoring well R-58; deploying tracers in groundwater at wells in TA-09 and TA-16; conducting extended aquifer testing at three wells; developing a groundwater investigation work plan with drilling work plans for two new regional wells (LANL 2016, 601779); and continuing to refine the site conceptual model. Following completion of the ongoing activities discussed in section 6.2, a revised CME report will be prepared and submitted to NMED.

3.1.1 Monitoring Well Installation

A regional aquifer monitoring well, R-58, was completed in TA-16 north of S-Site Canyon on November 5, 2015, and the well completion report for R-58 was submitted to NMED on March 28, 2016 (LANL 2016, 601364). Data from R-58 will be used to monitor contaminants downgradient of potential contaminant breakthrough locations for S-Site and Fishladder Canyons. Water-level data from R-58 will constrain the shape of the regional water table and groundwater flow directions in the area.

Regional groundwater was encountered at R-58 at a depth of 1240 ft below ground surface (bgs). Well R-58 is screened near the regional water table from 1257 to 1277.3 ft bgs. No perched groundwater was observed during the drilling of R-58.

Initial sampling data from R-58 showed elevated iron and lower-than-expected dissolved oxygen levels, suggesting the possible presence of reducing conditions at the well screen. Extended purge sampling events were conducted at R-58 in June and September 2016. During each event, R-58 was purged for 15 casing volumes, and time-series screening samples were collected. The R-58 analytical data are being evaluated, and representatives of the NMED Hazardous Waste Bureau (NMED-HWB) and the Laboratory will meet in the near future to review the data and to develop sampling recommendations for R-58.

3.1.2 Tracer Deployment and Sampling

Tracers were deployed in five screened intervals in monitoring wells R-25b, CdV-9-1(i) screen 1, CdV-9-1(i) Piezometers 1 and 2, and CdV-16-1(i) in accordance with the “Work Plan for a Tracer Test at Consolidated Unit 16-021(c)-99, Technical Area 16, Revision 1” (LANL 2015, 600535).

Although the tracer test work plan also included the deployment of a tracer in the surface water of Cañon de Valle, this tracer was not deployed. The Laboratory submitted a “Notice of Intent to Conduct a Tracer Test in the Cañon de Valle Surface Water/Alluvial System at Los Alamos National Laboratory, Technical Area 16” on August 6, 2015 (LANL 2015, 600870) to the NMED-SWQB. In a response letter to the Laboratory, dated September 11, 2015, NMED-SWQB neither approved nor disapproved the use of tracers in Cañon de Valle but advised the Laboratory to contact EPA Region 6 regarding federal permit requirements (NMED 2015, 600928). No determination regarding permitting conditions has been received from EPA.

Before the primary tracer was deployed, tracer dilution tests were conducted in R-25b and CdV-9-1(i) in early October 2015. Small quantities of naphthalene sulfonate (NS) tracer were introduced into the wells to characterize local well bore flow velocities to ensure the flow was sufficient to conduct long-term tracer deployments. Groundwater flow velocities were estimated at 0.05 m/d in R-25b and 2.6 m/d in CdV-9-1(i). A dilution test was also planned for CdV-16-1(i) but was not conducted because the pump configuration was not suitable for the test.

Large-scale (i.e., cross-borehole) tracer deployments were conducted at CdV-9-1(i) screen 1 and in the two CdV-9-1(i) piezometers in late October and early November, with the introduction of 40 kg of NS tracer and 150 kg of NaBr tracer in screen 1, and 25 kg of NS tracer in Piezometers 1 and 2. This deployment was followed by the introduction of 40 kg of NS tracer in R-25b in mid-November and 40 kg of NS tracer in CdV-16-1(i) in late November. Each well screen received a different compound of NS in accordance with the tracer test work plan (LANL 2015, 600535).

Tracer breakthrough sampling was conducted after the tracers were introduced. Groundwater was sampled for tracers at 11 locations, including 8 downgradient wells [CdV-16-4ip, CdV-16-2(i)r, R-47i, R-18, R-47, R-48, R-58 and R-63] and the 3 wells in which the tracers had been introduced [CdV-9-1(i),

CdV-16-1(i), and R-25b]. Tracer-breakthrough sampling was conducted 2 wk, 6 wk, and 12 wk after the tracers were deployed and quarterly thereafter. Tracer breakthrough samples were collected in December 2015, January 2016, March 2016, June 2016, and September 2016. A one-time tracer sampling event was also conducted at Westbay screens R-25 screen 1, screen 2, screen 4, and screen 5 in May 2016. Quarterly sampling for tracers is planned during the sampling events conducted under the Interim Plan in FY2017 (LANL 2016, 601506). A summary report of the tracer test and the relevant test data will be submitted to NMED by February 14, 2017, in accordance with Appendix B of the June 2016 Compliance Order on Consent (the Consent Order).

The tracer sampling results have demonstrated the importance of vertical flow paths at CdV-9-1(i) between the two piezometers and screen 1. Quarterly monitoring for tracers is planned for at least the next 2 yr to further quantify dispersal behavior from the injection wells and to monitor for any cross-well transport (i.e., verify lateral transport pathways).

3.1.3 Perched-Intermediate Groundwater Zone Aquifer Testing

Cross-borehole extended aquifer testing was conducted at three wells in accordance with the "Work Plan for Intermediate Groundwater System Characterization at Consolidated Unit 16-021(c)-9" (LANL 2015, 600686). Primary objectives of the testing are to evaluate the degree of hydraulic connectivity within the perched groundwater system and to improve the understanding of contaminant transport pathways. Monitoring wells CdV-9-1(i), CdV-16-1(i), and CdV-16-4ip were pumped for ~30 d each, and potentiometric responses were monitored in nearby perched-intermediate and regional wells. To assess transient responses in RDX concentrations, samples were collected from aquifer test wells during pumping and recovery.

Well CdV-9-1(i) was pumped from June 9 to July 12, 2016, and recovery samples were collected through July 25, 2016. Well CdV-16-1(i) was pumped from August 2 to August 30, 2016, and recovery samples were collected through September 23, 2016. Well CdV-16-4ip was pumped from September 6 to October 11, 2016, and recovery samples were collected through October 31, 2016.

The data from the perched-intermediate groundwater aquifer testing are currently being analyzed. Aquifer parameters and hydraulic connections between zones will be assessed, and temporal variations in RDX concentrations will be evaluated. A summary report and all relevant data will be submitted to NMED by April 7, 2017, in accordance with requirements under the Consent Order.

3.1.4 Groundwater Investigation Work Plan

On September 6, 2016, the Laboratory submitted the "Groundwater Investigation Work Plan for Consolidated Unit 16-021(c)-99, Including Drilling Work Plans for Wells R-68 and R-69" (LANL 2016, 601779) to address data needs identified based on new information from characterization activities at TA-09 and TA-16. The work plan proposed the installation of up to two regional aquifer monitoring wells, R-68 and R-69, north of Cañon de Valle and included drilling work plans for the two wells. The groundwater investigation work plan was approved by NMED on September 27, 2016 (NMED 2016, 601855).

The recommendation for new regional wells R-68 and R-69 were based on accelerating increases in RDX concentrations in R-18, along with unique ratios of HE-degradation products, indicating contamination in this well may originate from a source other than the 260 Outfall, with one possibility being historical releases from TA-09. In addition, screening data collected during drilling of CdV-9-1(i) showed the presence of a thick, high-RDX zone at a depth of ~650 to ~900 ft, indicating significant perched-intermediate groundwater north of Cañon de Valle.

Figure 3.1-1 shows the planned locations for R-68 and R-69 north of Cañon de Valle. The plan is to drill R-68 first, with drilling tentatively scheduled to start in December 2016, and to use the data from R-68 to prioritize the schedule for R-69. Well R-68 will be sampled immediately after development and aquifer testing, followed by one additional quarterly round of sampling. Data from the two sampling events as well as screening data collected during the drilling of R-68 will be assessed to determine the relative priority of, and the need for, R-69 to support the final CME report for TA-16.

3.1.5 Site Conceptual Model Refinement

During FY2016, characterization activities were conducted at TA-09 and TA-16 to refine the site conceptual model, including reevaluation of the RDX inventory based on recent data; geochemical studies; an in-depth review of the TA-16 geology; bioremediation and natural attenuation studies; and further improvements to the groundwater flow and contaminant transport models for TA-16. Additional details regarding these activities are provided below.

RDX Inventory Reevaluation

A revised estimate of the RDX mass in the vadose zone and groundwater at TA-16 was developed using updated analytical data that incorporates information from new monitoring wells in the TA-16 260 monitoring well network. Estimates of the RDX mass in the vadose zone and groundwater were first presented in 2006 in the "Investigation Report for Intermediate and Regional Groundwater, Consolidated Unit 16-021(c)-99" (LANL 2006, 093798). Considerable new data have been collected since 2006, including from the addition of new intermediate and regional monitoring wells. These data were used to update the RDX inventory estimate.

In addition, remediation activities were conducted during the 2009-2010 CMI to remediate HE and other contaminants at the 260 Outfall, reducing some of the available RDX inventory at the 260 Outfall (LANL 2010, 108868; LANL 2010, 110508). The RDX inventory reevaluation also accounted for this reduction in its revised estimate.

Two methods were used to estimate the RDX mass in soils and groundwater at TA-16. The first method used geographical information system and borehole data, and bounded the concentration ranges using a quartile approach. Because RDX concentration distributions are strongly skewed, quartiles were used instead of means and standard deviations. The second method used geostatistical methods and numerical modeling. This method utilized the existing geologic framework model with EarthVision software (Dynamic Graphics, 2015) to estimate volumes of contaminated groundwater and to spatially interpolate the subsurface distribution of RDX in three dimensions.

Both methods, although different in approach, yielded similar results, estimating the RDX mass in the subsurface to be on the order of several thousand kilograms. The RDX inventory estimate in 2016 ranged from 1467 kg to 2669 kg in soils, the vadose zone, perched-intermediate, and regional groundwater. The RDX inventory estimated in 2006 was considerably higher, ranging from 1520 kg to 23,334 kg (LANL 2006, 093798). The revised 2016 estimate of RDX mass and the relative distribution of RDX in each hydrologic zone will be used to target corrective actions proposed in the final CME report for TA-16.

Geochemical Studies

Geochemical evaluations were conducted on groundwater analytical data from springs and alluvial, perched-intermediate, and regional monitoring wells. Geochemical conditions play a strong role in controlling breakdown of HE in the subsurface. Graphical and statistical approaches were used to understand similarities and differences between the various components of the TA-16 hydrogeological

system. Such data are useful for understanding the hydrological flow path and the relative importance of local recharge versus mountain front recharge, which has major implications for HE concentrations and transport. Mountain-front recharge is the contribution from mountains to groundwater recharge of the adjacent basin along the mountain front.

The results of these ongoing studies indicate that while general similarities exist across hydrological components at TA-16 in terms of major ion chemistry, statistically significant differences exist for certain ions and/or HE species between the different components (including the upper and lower perched intermediate zones). These results indicate the components are affected by the different geological units in the area (through water/rock interactions), and the degree of mountain-front recharge contribution. Clear trends in chloride and lithium suggest the perched-intermediate zones, and especially the regional aquifer, have much larger contributions of high elevation/mountain-front recharge than the shallower zones.

To further evaluate the impacts of mountain-front recharge, quarterly stream discharge measurements were conducted in upper Cañon de Valle to quantify infiltration to the subsurface above the Pajarito fault. In addition, a comprehensive review of the isotope hydrology data for the TA-16 area was initiated. The δ^2H and $\delta^{18}O$ results are consistent with a large mountain-front recharge component in the regional aquifer.

The geochemical studies provide a better understanding of how RDX and other contaminants migrate along various hydrologic flow paths and complement the data collected in the ongoing tracer study and the cross-hole aquifer test study at TA-16. The geochemical, isotope, and stream discharge data are being used to further refine the site conceptual model to evaluate the potential for HE degradation. This revised site conceptual model and the results of the ongoing geochemical studies will provide information for the final CME report for TA-16.

Geological Studies

Geological studies to compile data in support of the final CME report were completed in FY2016. The focus of the geologic studies was to improve the site geologic model and to provide a summary of geologic conditions at TA-16. Emphasis was placed on geologic features that influence groundwater pathways and flow directions such as fractures, structures, and bedding orientations.

Three primary tasks were accomplished in FY2016. First, the stratigraphic contacts within the Bandelier Tuff and the Cerro Toledo Formation were updated using data from microscopic analysis of borehole cuttings, lithologic examinations of cores, chemical fingerprinting of pumice, and reviews of geophysical logs. Second, the updated contacts were used to make cross-well correlations and develop structural contour maps showing internal bedding orientations and the dips of individual flow units. Finally, the updated stratigraphic contacts and the internal bedding surfaces and orientations data were summarized in an internal geology report for TA-16, which will be incorporated into the final CME report.

Major findings included the following: (1) percolation of groundwater through the vadose zone will tend to stair-step towards the east and southeast along bedding contacts before entering the upper deep perched groundwater zone, (2) flow directions for perched groundwater in the upper deep perched groundwater zone are likely to be towards the southeast based on the orientation of potential confining or semiconfining beds, and (3) faults and fractures are likely to be primary pathways for recharge through strongly welded tuffs that underlie Cañon de Valle. These data contribute to the site conceptual model about contaminant recharge pathways and will help constrain the placement and locations of future wells targeting deep perched groundwater in the area, should they be necessary.

Natural Attenuation and Bioremediation Studies

The microbial diversity in perched-intermediate and regional groundwater was evaluated to examine natural attenuation and remedial alternatives for RDX at TA-16. Bench-scale experiments were conducted to examine the kinetics and mechanisms of RDX degradation. Osorb samplers were deployed at select wells to examine RDX degradation and to compare the results to the data obtained from groundwater monitoring. Osorb samplers use a resin to accumulate organic compounds, including HE and associated degradation products, amplifying the concentrations that can be detected.

Data from these studies indicate that groundwater at TA-16 has a healthy population of microbes, including microbes known to degrade RDX. In situ sampling using Osorb samples suggests that natural RDX degradation under TA-16 conditions may be more pronounced than what was originally observed through routine groundwater monitoring.

Laboratory tests of degradation under biostimulated conditions were also conducted and demonstrated that vegetable oil stimulates microbial activity and increases the degradation of RDX. However, strict anaerobic conditions are required to stimulate RDX degradation, which might be difficult to implement given the oxidizing conditions that dominate groundwater in the TA-16 area.

Groundwater Flow and Transport Modeling

During FY2016, additional refinements were made to the analytical and numerical models of groundwater flow and contaminant transport for TA-16. The vadose zone model was updated to incorporate the results from the latest geologic studies, and uncertainties regarding infiltration of recharge along Cañon de Valle and along the mountain front were assessed. Some analysis of the cross-hole aquifer test data was conducted and is ongoing. In addition, a new technique, blind source separation (BSS), was used to analyze geochemical data and to evaluate possible multiple sources for contamination in perched-intermediate and the regional groundwater at TA-16 and TA-09.

4.0 REGULATORY, PUBLIC, AND STAKEHOLDER INVOLVEMENT

Technical meetings with the NMED-HWB and the NMED DOE Oversight Bureau (NMED DOE-OB) were held throughout the year to discuss RDX project activities. These meetings are summarized below:

12/08/2015	Meeting with the NMED DOE-OB to review RDX geochemistry studies
12/14/2015	Meeting with NMED-HWB to discuss strategy for closing out remaining issues related to the 2009–2010 CMI at Consolidated Unit 16-021(c)-99 within TA-16 (LANL 2010, 108868)
03/17/2016	Meeting with the NMED DOE-OB to review the Osorb data collected for the RDX project
04/05/2016	Site visit to Cañon de Valle with the NMED-HWB to assess alluvial well network and PRB cleanup requirements
06/28/2016	Presentation to NMED DOE-OB and NMED-HWB regarding the ongoing RDX studies, including data needs and the ongoing studies to support the CME
08/03/2016	Meeting with NMED DOE-OB and NMED-HWB to discuss the groundwater investigation work plan and proposed regional wells R-68 and R-69
09/15/2016	Meeting with NMED-HWB to discuss the “Evaluation Report for Surface Corrective Measures Implementation Closure, Consolidated Unit 16-021(c)-99” (LANL 2016, 601837)

In addition, the Laboratory met with the NMED Groundwater Quality Bureau during the development of the "Work Plan for Treatment and Land Application of Groundwater from Technical Areas 09 and 16, DP-1793, WP #4" (LANL 2016, 601357). Meetings were held on April 11 and May 10, 2016, to discuss the sampling and land-application requirements for treated groundwater from the planned extended aquifer tests at TA-09 and TA-16.

Lastly, permit RG-96063 was obtained from the New Mexico Office of the State Engineer to allow the aquifer testing of wells CdV-9-1(i), CdV-16-4ip, and CdV-16-1(i) for a maximum of 30 cumulative days each. The total diversion amount was not to exceed 1.54 acre-feet, and the extended pumping period was granted from June 3 to October 31, 2016.

5.0 PROBLEMS ENCOUNTERED

No significant problems were encountered during the FY2016 reporting period.

6.0 WORK PLANNED FOR THE NEAR FUTURE

6.1 Surface CMI Activities

6.1.1 BMPs

- Continue to inspect current BMPs annually and following significant rain events of 0.25 in. or greater within 30 min, as measured at rain gage RG257, per the Individual Permit.

6.1.2 Hydrogeologic Investigations

- Continue groundwater monitoring in accordance with the requirements of the monitoring year 2017 Interim Plan (LANL 2016, 601506).
- Continue precipitation monitoring.

6.1.3 CMI Closure Activities

- Implement the recommendations of the "Evaluation Report for Surface Corrective Measures Implementation Closure, Consolidated Unit 16-021(c)-99" (LANL 2016, 601837). These recommendations include removing the damaged PRB in Cañon de Valle, plugging and abandoning PRB alluvial monitoring wells, installing hand-augered alluvial monitoring well CdV-16-02657r, removing the spring carbon filters, and restoring the site at SWSC, Burning Ground, and Martin Springs.
- Prepare a surface CMI closure report for Consolidated Unit 16-021(c)-99 once all surface CMI closure activities have been completed. The report will be submitted to NMED by September 15, 2017.

6.2 Ongoing Activities to Fill Investigation Gaps for the Final CME

- Continue quarterly monitoring for tracers at select downgradient wells, and at the wells in which the tracers were introduced. Samples will be collected during routine Interim Plan sampling.
- Prepare a summary report of the RDX tracer deployment activities for submittal to NMED by February 14, 2017.

- Analyze the data from the cross-hole aquifer testing at CdV-9-1(i), CdV-16-4ip, and CdV-16-1(i) and prepare the aquifer test summary report, to be submitted to NMED by April 7, 2017.
- Install regional monitoring well R-68 north of Cañon de Valle, complete aquifer testing of the new well, and collect two quarters of data.
- Based on the data from R-68, make a determination regarding the relative priority for drilling R-69 and whether these data are needed to complete the final CME report.
- Continue with the ongoing geochemical studies to update the site conceptual model.
- Continue the ongoing RDX degradation studies and treatability studies to determine if enhanced bioremediation techniques can be used to remediate RDX at TA-16.
- Continue the update of the groundwater flow and contaminant transport models to be used for evaluation of remedial alternatives for the final CME report and to predict future contaminant concentrations in perched-intermediate and regional groundwater.
- Complete the BSS studies to further explore the possibility of multiple contaminant sources for increasing concentrations of contaminants in the regional aquifer at R-18.
- Prepare final CME report, with recommendations for RDX remedies for surface and subsurface at Consolidated Unit 16-021(c)-99.

6.3 Public and Stakeholder Involvement

- Continue to hold regular technical meetings with NMED DOE-OB and NMED-HWB to discuss technical issues related to the RDX project and to provide updates on the tracer test results, modeling activities, and fieldwork related to closing out the surface CMI activities.

7.0 REFERENCES

The following list includes all documents cited in this report. 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.

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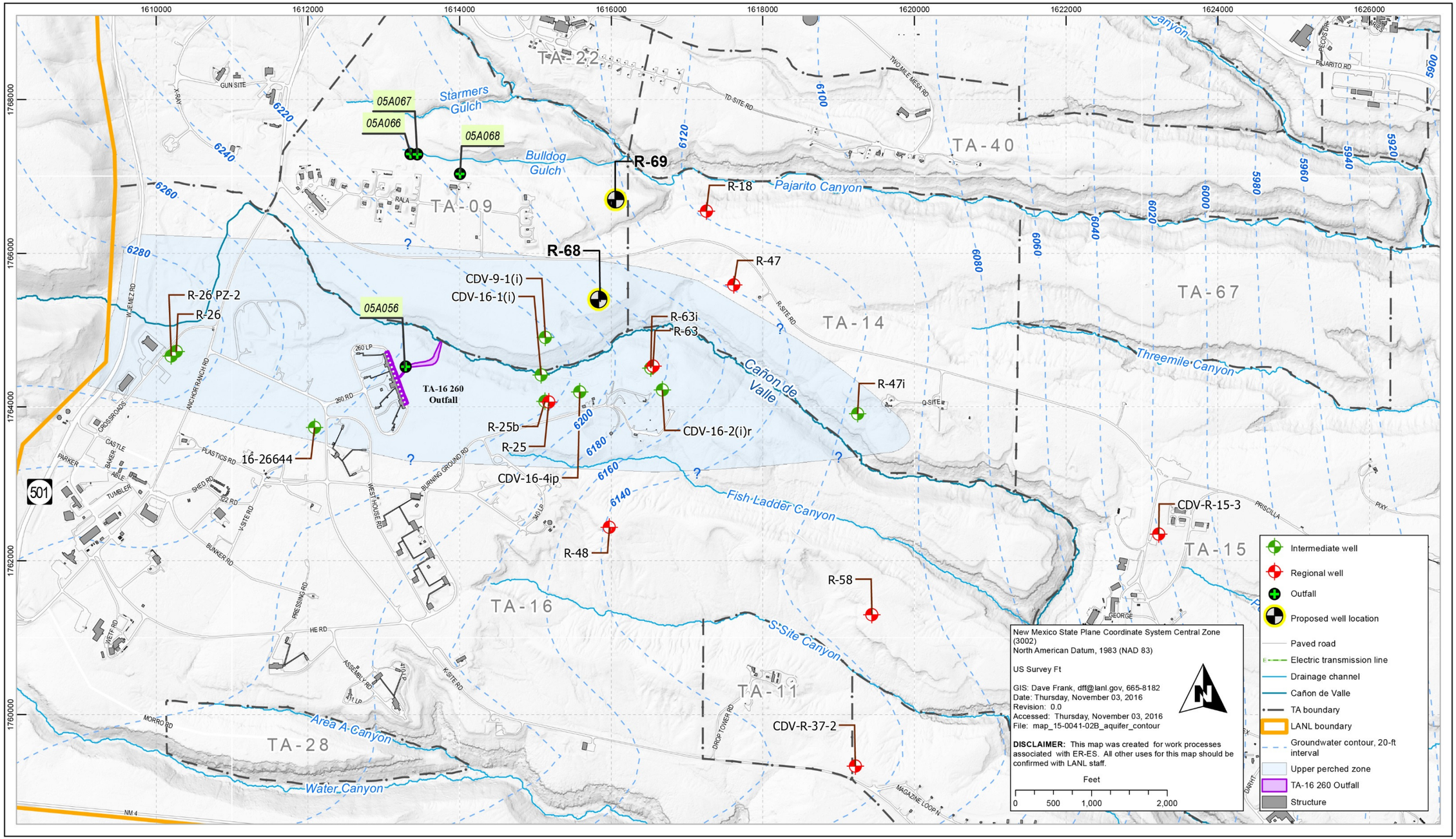

Figure 3.1-1 Planned locations for R-68 and R-69 north of Cañon de Valle