ESHID-600934

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RECEIVED
SEP 29 2015
NMED
Hazardous Waste Bureau

Environmental Management
Los Alamos Field Office, MS A316
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Date: SEP 29 2015
Refer To: ADESH-15-129
LAUR: 15-26729
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: Submittal of the Completion Report for Intermediate Aquifer Well R-63i

Dear Mr. Kieling:

Enclosed please find two hard copies with electronic files of the Completion Report for Intermediate Aquifer Well R-63i. On July 7, 2015, the staff of the New Mexico Environment Department Hazardous Waste Bureau agreed the well completion report would be submitted without specifications for a dedicated sampling system. Your staff was informed that this well does not support the installation of a dedicated sampling system because of its low yield and approved the report. Groundwater-level monitoring will be conducted at this location.

If you have any questions, please contact Steve Paris at (505) 606-0915 (smparis@lanl.gov) or Hai Shen at (505) 665-5046 (hai.shen@em.doe.gov).

Sincerely,

for B. Robinson
Bruce Robinson, Program Director
Environmental Remediation Program
Los Alamos National Laboratory

Sincerely,

for
Douglas E. Hintze, Manager
Environmental Management
Los Alamos Field Office

BR/DH/SP:sm

Enclosures: Two hard copies with electronic files – Completion Report for Intermediate Aquifer Well R-63i (EP2015-0154)

Cy: (w/enc.)
emla.docs@em.doe.gov
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Public Reading Room (EPRR)
ADESH Records

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Dino Chavarria, Santa Clara Pueblo
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LA-UR-15-26729
September 2015
EP2015-0154

Completion Report for Intermediate Aquifer Well R-63i

Los Alamos
NATIONAL LABORATORY
EST. 1943

Prepared by the Environmental Programs Directorate

EP2015-0154

Completion Report for Intermediate Aquifer Well R-63i

September 2015

Responsible project manager:

Printed Name	Signature	Title	Organization	Date
Steve Paris		Project Manager	Environmental Remediation Program	9/24/2015

Responsible LANS representative:

Printed Name	Signature	Title	Organization	Date
Randall Erickson	for R. Erickson	Acting Associate Director	Environmental Programs	9/24/15

Responsible DOE representative:

Printed Name	Signature	Title	Organization	Date
Douglas E. Hintze		Manager	DOE-EM-LA	9-28-2015

EXECUTIVE SUMMARY

This well completion report describes the drilling, well construction, and development for perched-intermediate aquifer groundwater well R-63i, located within Los Alamos National Laboratory Technical Area 16 (TA-16) in Los Alamos County, New Mexico. The R-63i monitoring well is intended to monitor contaminant releases from the 260 Outfall and Material Disposal Area P as well as recharge from Cañon de Valle, as required by the New Mexico Environment Department's (NMED's) approval with modifications for the TA-16 well network evaluation and recommendations report.

The R-63i borehole was drilled using rotary and dual-rotary air-drilling methods. Fluid additives used included potable water and foam. Foam-assisted drilling was used only to a depth of 974 ft below ground surface (bgs), approximately 100 ft above the top of the perched-intermediate aquifer.

The following geologic formations were encountered at R-63i: Tshirege Member of the Bandelier Tuff, Cerro Toledo interval, Otowi Member of the Bandelier Tuff, Guaje Pumice Bed of the Otowi Member, and Puye Formation volcaniclastic sediments. R-63i was drilled to a total depth of 1245 ft bgs.

Well R-63i was completed as a single-screen well, allowing water quality and water levels within the perched-intermediate aquifer to be evaluated. The screened interval is set between 1122.5 and 1189.0 ft bgs within Puye Formation sediments. The static depth to water after well installation was measured at 1175.9 ft bgs.

The well was completed in accordance with the NMED-approved well design. The well was developed but the intermediate aquifer groundwater did not meet target water-quality parameters. Aquifer testing was not conducted, and a sampling system was not installed because of the low productivity of the screened interval. Groundwater will be sampled with a non-dedicated sampling system at R-63i as part of the annual Interim Facility-wide Groundwater Monitoring Plan.

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Acronyms and Abbreviations

amsl	above mean sea level
ASTM	American Society for Testing and Materials
BDL	below detection limit
bgs	below ground surface
Consent Order	Compliance Order on Consent
DO	dissolved oxygen
DTW	depth to water
EES	Earth and Environmental Sciences (Laboratory group)
Eh	oxidation-reduction potential
EP	Environmental Programs
EPA	Environmental Protection Agency (U.S.)
ESH	Environment, Safety, and Health (Laboratory directorate)
gpm	gallons per minute
HE	high explosives (also HEXP)
I.D.	inside diameter
LANL	Los Alamos National Laboratory
MDA	material disposal area
NAD	North American Datum
NMED	New Mexico Environment Department
NTU	nephelometric turbidity unit
O.D.	outside diameter
ORP	oxidation-reduction potential
RDX	hexahydro-1,3,5-trinitro-1,3,5-triazine
TA	technical area
TD	total depth
TOC	total organic carbon
WCSF	waste characterization strategy form

1.0 INTRODUCTION

This completion report summarizes borehole drilling, well construction, and well development for intermediate aquifer monitoring well R-63i. The report was prepared in accordance with the requirements in Section IV.A.3.e.iv of the March 1, 2005 (revised 2012), Compliance Order on Consent (the Consent Order). The R-63i monitoring well borehole was drilled from August 1 to October 9, 2014, and completed from October 14 to November 10, 2014, at Los Alamos National Laboratory (LANL or the Laboratory) for the Laboratory's Environmental Programs (EP) Directorate.

Well R-63i is located within Technical Area 16 (TA-16) of the Laboratory in Los Alamos County, New Mexico (Figure 1.0-1). Well R-63i was installed to monitor contaminant releases from the 260 Outfall and MDA P as well as recharge from Cañon de Valle. Secondary objectives were to establish water levels in the intermediate aquifer, to identify potential perched aquifers, and to collect samples of drill cuttings for lithologic description.

The R-63i borehole was drilled to a total depth (TD) of 1245 ft below ground surface (bgs). During drilling, cuttings samples were collected at 5-ft intervals in the borehole from ground surface to TD. A monitoring well was installed with a screened interval between 1122.5 and 1189.0 ft bgs within Puye Formation sediments. The depth to water (DTW) of 1175.9 ft bgs was recorded on November 11, 2014, after well installation.

Post-installation activities included well development, surface completion, and conducting a geodetic survey. Future activities will include site restoration and waste management.

The information presented in this report was compiled from field reports and daily activity summaries. Records, including field reports, field logs, and survey information, are on file at the EP Records Processing Facility. This report contains brief descriptions of activities and supporting figures, tables, and appendixes associated with the R-63i project.

2.0 ADMINISTRATIVE PLANNING

The following documents were prepared to guide activities associated with the drilling, installation, and development of intermediate aquifer well R-63i:

- "Drilling Work Plan for Well R-63i" (LANL 2013, 235924);
- "Field Implementation Plan for Intermediate Well R-63i"(TerranearPMC 2013, 524579);
- "IWD for Drilling and Installation of LANL Wells R-63i, R-47, and CdV-9-1i" (TerranearPMC 2014, 262889);
- "Storm Water Pollution Prevention Plan for Regional Well Drilling" (LANL 2006, 092600); and
- "Waste Characterization Strategy Form: R-47, R-58, R-63i, CdV-9-1i" (LANL 2013, 244887).

3.0 DRILLING ACTIVITIES

This section describes the drilling approach and provides a chronological summary of field activities conducted at monitoring well R-63i.

3.1 Drilling Approach

The drilling method, equipment and drill-casing sizes for the R-63i monitoring well were selected to retain the ability to investigate and case off any perched groundwater encountered above the target intermediate aquifer. Further, the drilling approach ensured that a sufficiently sized drill casing was used to meet the required 2-in. minimum annular thickness of the filter pack around a 5.88-in. outside-diameter (O.D.) well screen.

Both rotary, using an LM140 drill rig, and dual-rotary, using a Foremost DR24HD drill rig, air-drilling methods were employed to drill the R-63i borehole. Dual-rotary drilling has the advantage of simultaneously advancing and casing the borehole. The drill rigs were equipped with conventional drilling rods, tricone bits, downhole hammer bits, a deck-mounted air compressor, and general drilling equipment. Auxiliary equipment included two Ingersoll Rand skid-mounted air compressors. Four sizes of A53 grade B flush-welded mild carbon steel casing (24-in., 18-in., and 16-in.outside diameter (O.D.), and 12-in. inside diameter [I.D.]) were used for the R-63i project.

Rotary and dual-rotary drilling techniques at R-63i used filtered compressed air and fluid-assisted air to evacuate cuttings from the borehole during drilling. Drilling fluids, other than air, used in the borehole (all within the vadose zone) included potable water and a mixture of potable water with Baroid AQF-2 foaming agent. The fluids were used to cool the bit and help lift cuttings from the borehole. Use of the foaming agent was terminated at 974 ft bgs, roughly 100 ft above the expected top of the target intermediate aquifer. When cuttings could not be lifted at 1025 ft bgs, drilling was suspended. A small amount (~1 gal.) of foaming agent was used inside the 16-in. casing string to assist in lifting cuttings before drilling recommenced. Total amounts of drilling fluids introduced into the borehole are presented in Table 3.1-1.

3.2 Chronological Drilling Activities for the R-63i Well

Drilling equipment and supplies were mobilized to the R-63i drill site on August 1, 2014. Decontamination of the equipment and tooling was performed before mobilization to the site. On August 1, following on-site equipment inspections, the monitoring well borehole was initiated at 2015 h using rotary open-hole methods with a 28-in. tricone bit.

The 28-in. open-hole drilling continued to 59 ft bgs in Unit 3 of the Tshirege Member of the Bandelier Tuff, and 24-in. surface casing was then installed to 59.8 ft bgs. Bentonite and drill cuttings were used to fill the annulus around the surface casing.

On August 2, open-hole drilling commenced using a 22-in. tricone bit. Drilling proceeded through the Tshirege Member of the Bandelier Tuff, the Cerro Toledo interval, the Otowi Member of the Bandelier Tuff, and into the Puye Formation to 709 ft bgs on August 4.

The LM140 drill rig was removed from the R-63i drill site on August 8. No drilling activities occurred at R-63i from August 9 to September 5. On September 6, a Pulstar P100K work-over rig was mobilized to R-63i to hang an 18-in. casing string in the open borehole. The work-over rig was used to hang 559 ft of 18-in. casing before the Foremost DR24HD dual-rotary rig was mobilized to the site on September 12. Between September 12 and September 13, the remaining 18-in. casing string was installed in the open borehole to a depth of 695 ft bgs. From September 14 to September 18, an 18-in. underreaming hammer bit was used to advance the 18-in. casing through the Otowi Member of the Bandelier Tuff, the Guaje Pumice of the Otowi Member, and through a potential perched aquifer in the Puye Formation to 852 ft bgs. After drilling to 852 ft bgs, 80 ft of cuttings were measured inside the 18-in. casing string. The cuttings were drilled out with a 17-in. tricone bit to 850 ft bgs and the 18-in. casing was cut at 847 ft bgs on September 19.

The 18-in. casing was pulled up 5 ft and a bentonite seal was installed through a tremie pipe around the 18 in. casing shoe. The 18-in. casing was then pushed back through the bentonite to the top of the 18-in. shoe at 847 ft bgs. The bentonite seal was tagged at 838 ft bgs, creating a 12 ft seal below the potential perched zone.

Between September 20 and September 22, a 16-in. casing string was installed inside the 18-in. casing string. Starting September 23, a 16-in. underreaming hammer bit was used to advance the 16-in. casing string through the bentonite seal and the Puye Formation. Use of drilling foam while drilling was discontinued at a depth of 974 ft bgs, approximately 100 ft above the expected target intermediate aquifer depth. Below 974 ft, the drill crew had difficulty getting cuttings to the surface by circulating air and water. A small amount of foam was added below 974 ft while the bit was retracted into the 16-in. casing string to help lift cuttings to the surface. The 16-in. casing was advanced to a total depth of 1027.7 ft bgs, below a potential perched aquifer, on September 25. On September 26, the 16-in. casing shoe was cut at 1022.8 ft bgs. The 16-in. casing was retracted 9 ft and on September 27 a bentonite seal was installed around the 16-in. casing shoe before the 16-in. casing was lowered back to the casing shoe cut at 1022.8 ft bgs. The bentonite seal was tagged at 1014 ft bgs, creating a 14-ft seal below the potential perched zone.

Between September 27 and September 29, a 12-in. casing string was installed inside the 16-in. casing string. Starting on September 29, the 12-in. casing was advanced with an underreaming hammer bit through the Puye Formation to a depth of 1175 ft bgs on October 1. A perched aquifer was encountered at approximately 1175 ft bgs and drilling was suspended to monitor water levels in this zone and record geophysical logs. On October 3, the 12-in. casing was advanced to 1225 ft bgs. Drilling was again suspended to monitor water levels and record geophysical logs. On October 7, the 12-in. casing was advanced to 1245 ft bgs. Drilling was again suspended to monitor water levels and record geophysical logs after pulling the 12-in. casing back 80 ft. On October 9, the casing was reinstalled to a total depth of 1243.3 ft bgs.

During drilling, field crews worked 24-h shifts, 7 d/wk. All associated activities proceeded normally without incident or delay.

4.0 SAMPLING ACTIVITIES

This section describes the cuttings and groundwater sampling activities for monitoring well R-63i. All sampling activities were conducted in accordance with applicable quality procedures.

4.1 Cuttings Sampling

Cuttings samples were collected from the R-63i monitoring well borehole at 5-ft intervals from ground surface to the TD of 1245 ft bgs. At each interval, the site geologist collected approximately 500 mL of bulk cuttings from the drilling discharge cyclone, placed them in resealable plastic bags, and labeled and archived in core boxes. Whole rock, +35 and +10 sieve size fractions were also processed, placed in chip trays, and archived for each 5-ft interval. Radiation control technicians screened the cuttings before removal from the site. All screening measurements were within the range of background values. The cuttings samples were delivered to the Laboratory's archive at the conclusion of drilling activities.

The stratigraphy at R-63i is summarized in section 5.1, and a detailed lithologic log is presented in Appendix A.

4.2 Water Sampling

Eight groundwater samples were collected during drilling and analyzed for RDX (hexahydro-1,3,5-trinitro-1,3,5-triazine). Two groundwater samples were collected from a bailer after well development for analysis of anions, metals, RDX, and total organic carbon (TOC).

Table 4.2-1 presents a summary of screening samples collected during the R-63i monitoring well installation. The TOC results and field water-quality parameters are presented in Appendix B.

Because of the limited groundwater productivity at R-63i, the current approved Interim Facility-Wide Groundwater Monitoring Plan (LANL 2014, 256728; NMED 2015, 600154) commits to collecting water-level information only at this well. Should conditions change and sufficient groundwater is available for sampling, a non-dedicated sampling system will initially be used to collect screening samples. Long-term monitoring at this well will be considered only after 2 yr of water-level data and screening samples, if any, have been collected and evaluated.

5.0 GEOLOGY AND HYDROGEOLOGY

A brief description of the geologic and hydrogeologic features encountered at R-63i is presented below. The Laboratory's geology task leader and project site geologist examined cuttings to determine geologic contacts and hydrogeologic conditions. Drilling observations and water-level measurements were used to characterize groundwater encountered at R-63i.

5.1 Stratigraphy

Rock units for the R-63i borehole are presented below in order of youngest to oldest in stratigraphic occurrence. Lithologic descriptions are based on binocular microscope analysis of drill cuttings collected from the discharge hose. Figure 5.1-1 illustrates the stratigraphy at R-63i. A detailed lithologic log for R-63i is presented in Appendix A.

Unit 4, Tshirege Member of the Bandelier Tuff, Qbt 4 (0–77 ft bgs)

Unit 4 of the Tshirege Member of the Bandelier Tuff was encountered from 0 to 77 ft bgs. Unit 4 is a distinctive tuff that consists of a basal, crystal-rich, pyroclastic surge deposit overlain by pumice-poor ash-flow tuffs.

Unit 3, Tshirege Member of the Bandelier Tuff, Qbt 3 (77–200 ft bgs)

Unit 3 of the Tshirege Member of the Bandelier Tuff was encountered from 77 to 200 ft bgs. Unit 3 is a poorly to moderately welded devitrified ash-flow tuff (i.e., ignimbrite) that is crystal-rich, slightly pumiceous and lithic-poor and exhibits a matrix of fine ash.

Unit 2, Tshirege Member of the Bandelier Tuff, Qbt 2 (200–310 ft bgs)

Unit 2 of the Tshirege Member of the Bandelier Tuff was intersected from 200 to 310 ft bgs. Unit 2 represents a moderately to strongly welded devitrified rhyolitic ash-flow tuff (i.e., ignimbrite) that is composed of abundant (up to 40% by volume) quartz and sanidine crystals. Cuttings typically contain abundant fragments of indurated tuff and numerous free quartz and sanidine crystals.

Unit 1v, Tshirege Member of the Bandelier Tuff, Qbt 1v (310–340 ft bgs)

Unit 1v of the Tshirege Member of the Bandelier Tuff occurs from 310 to 340 ft bgs. Unit 1v is a poorly to moderately welded, devitrified rhyolitic ash-flow tuff that is pumiceous, generally lithic-poor and crystal-bearing to locally crystal-rich. Abundant ash matrix is rarely preserved in cuttings. Cuttings commonly contain numerous fragments of indurated crystal-rich tuff with devitrified pumice. Abundant free quartz and sanidine crystals dominate cuttings in many intervals and minor small (generally less than 10 mm in diameter) volcanic lithic inclusions also occur in cuttings

Unit 1g, Tshirege Member of the Bandelier Tuff, Qbt 1g (340–360 ft bgs)

Unit 1g of the Tshirege Member of the Bandelier Tuff was encountered from 340 to 360 ft bgs. Unit 1g is a poorly welded vitric rhyolitic ash-flow tuff that is poorly to moderately indurated, strongly pumiceous, and crystal-bearing. White to pale orange, lustrous, glassy pumice lapilli are characteristic of Unit 1g. Cuttings contain abundant free quartz and sanidine crystals and minor small (up to 10 mm) volcanic (predominantly dacitic) lithic inclusions.

Cerro Toledo Interval, Qct (360–700 ft bgs)

The Cerro Toledo interval was encountered from 360 to 700 ft bgs. The Cerro Toledo interval is a sequence of poorly consolidated tuffaceous and volcaniclastic sediments that occurs regionally between the Tshirege and Otowi Members of the Bandelier Tuff. The Cerro Toledo interval at R-63i contains grayish orange to white pumice clasts and various dacitic and rhyolitic clasts. Silt and sand-size grains are dominated by angular to subangular quartz and sanidine grains. Sediments are largely stained with orange oxidation on grain surfaces.

Otowi Member of the Bandelier Tuff, Qbo (700–787 ft bgs)

The Otowi Member of the Bandelier Tuff was encountered from 700 to 787 ft bgs. The Otowi Member is composed of poorly welded vitric rhyolitic ash-flow tuffs that are pumiceous and crystal- and lithic-bearing. Drill cuttings contain pale orange glassy pumices, volcanic lithic clasts (up to 10 mm), and quartz and sanidine crystals. Lithic fragments are commonly subangular to subrounded and generally of intermediate volcanic composition, including porphyritic dacites.

Guaje Pumice Bed of the Otowi Member of the Bandelier Tuff, Qbog (787–796 ft bgs)

The Guaje Pumice Bed represents an air-fall tephra deposit of rhyolitic pumice that forms the base of the Otowi Member. The Guaje deposit was encountered from 787 to 796 ft bgs. Drill cuttings in this interval contain abundant (up to 90% by volume), lustrous, vitric pumice lapilli (up to 15 mm in diameter) with trace occurrences of small volcanic lithic fragments. The deposit is poorly consolidated.

Puye Formation, Tpf (796–1245 ft bgs)

Puye Formation volcaniclastic sediments were encountered from 796 to the total borehole depth of 1245 ft bgs. The Puye Formation consists of alluvial fan deposits eroded from volcanic rocks in the nearby Jemez Mountains. Cuttings from this interval consist of grey, red, and purple dacitic and rhyolitic gravels, volcaniclastic sands, and minor devitrified pumice clasts. Cuttings are generally angular to subangular. These deposits likely contain intervals with cobbles and boulders, but these larger clasts are pulverized during drilling.

5.2 Groundwater

Drilling at R-63i proceeded without any groundwater indications until 755 ft bgs when possible perched water was noted by the drilling crew while advancing 18-in. casing. Up to 1.5 gallons per minute (gpm) was observed between 755 and 775 ft bgs. The drill crew reported perched water at 864 ft bgs and observed rates of up to 3 gpm while 16-in. casing was advanced. Perched water was also encountered at 1025 ft bgs while advancing 16-in. casing, and water production was estimated at 8 gpm. While the 12-in. casing advance was drilled, the target intermediate aquifer was encountered from 1175 to 1180 ft bgs. Water was encountered again from 1200 ft bgs to 1225 ft bgs, based on drill crew observations. After a 2-d pause to monitor water levels and record geophysical logs, the borehole was advanced to the TD of 1245 ft bgs.

On October 13, 2014, the water level was 1187.2 ft bgs. From October 14 to 15, bentonite chips were installed from 1236.8 to 1213.2 ft bgs to evaluate water levels in the perched zones. On October 16 and 17, water was bailed from the well casing and borehole and water levels were monitored to determine recharge rate and static water level. The water level was 1123.3 ft bgs on October 18 before well installation.

6.0 BOREHOLE LOGGING

Natural gamma logs were recorded in the borehole on October 2, 2014, from surface to 1175 ft bgs inside the 12-in. casing (Appendix C). Natural gamma logs, induction logs, and video logs were recorded on October 5. The video log was recorded from surface to 1183 ft bgs. The induction log was recorded from 1220 to 1190 ft bgs. The natural gamma log was recorded from 1220 ft bgs to the surface. During logging the borehole was open below the 12-in. casing at 1104 ft bgs (Appendixes C and D). Induction and video logs were also recorded on October 8. The video log was recorded from 1160–1200 ft bgs, and the induction log was recorded from 1241 to 1160 ft bgs in open borehole below the 12-in. casing (Appendixes C and D). Logging was conducted with Laboratory logging equipment and personnel.

7.0 WELL INSTALLATION R-63i MONITORING WELL

The R-63i well was constructed between October 14 and November 10, 2014.

7.1 Well Design

The R-63i well was designed in accordance with the Consent Order, and NMED approved the final well design before installation (Appendix E). The well was designed with a screened interval between 1122.5 and 1189.0 ft bgs to monitor the groundwater quality near the top of the perched-intermediate aquifer within the Puye Formation.

7.2 Well Construction

From October 11 to 18, 2014, the stainless-steel well casing, screens, and tremie pipe were decontaminated, and the Pulstar workover rig and initial well construction materials were mobilized to the site.

The R-63i monitoring well was constructed of 5.0-in. I.D./5.56-in. O.D., type A304 passivated stainless-steel threaded casing fabricated to American Society for Testing and Materials (ASTM) A312 standards. The screened section utilized six 10-ft lengths of 5.0-in.-I.D. rod-based 0.040-in. wire-wrapped screens to make up the 66.5-ft-long screen interval. Compatible external stainless-steel couplings (also type A304

stainless-steel fabricated to ASTM A312 standards) were used to join the individual casing sections. The coupled unions between threaded sections were approximately 0.5 ft long. A 2-in. steel tremie pipe was used to deliver backfill and annular fill materials down-hole during well construction. A short length of 18-in. (5-ft casing and shoe, from 847.0 to 852.0 ft bgs) and 16-in. drill casing (4.9-ft casing and shoe, from 1022.8 to 1027.7 ft bgs) remain in the borehole. The 18-in. casing stub and the 16-in. casing stub were encased in the upper bentonite seal during well completion.

A 22.6-ft-long stainless-steel sump was placed below the bottom of the well screen. The well casing was started into the borehole on October 19 at 0730 h. The well casing was hung by wireline with the bottom at 1211.6 ft bgs. Stainless-steel centralizers (two sets of four) were welded to the well casing approximately 2.0 ft above and below the screened interval. Figure 7.2-1 presents an as-built schematic showing construction details for the completed well.

The installation of backfill materials began on October 14 after the bottom of the borehole was measured at 1236.8 ft bgs (approximately 8.2 ft of slough had accumulated in the borehole). The lower bentonite seal was installed between October 14 and 21 from 1194.1 to 1236.8 ft bgs using 36.4 ft^3 of 3/8-in. bentonite chips.

The filter pack was installed between October 21 and 23 from 1117.6 to 1194.1 ft bgs using 73.8 ft^3 of 10/20 silica sand. The actual volume of filter pack sand was 12% greater than the calculated volume and is likely the result of an oversized borehole caused by sloughing in the Puye Formation during drilling. The filter pack was surged to promote compaction. The fine-sand collar was installed above the filter pack from 1115.5 to 1117.6 ft bgs using 1.6 ft^3 of 20/40 silica sand.

From October 23 to November 7, the upper bentonite seal was installed from 62.6 to 1115.5 ft bgs using 1809.5 ft^3 of 3/8-in. bentonite chips. On November 9 and 10, a cement seal was installed from 3.0 to 62.6 ft bgs. The cement seal used 213.9 ft^3 of Portland Type I/II/V cement. This volume exceeded the calculated volume of 175.6 ft^3 by 22% and is likely from cement loss to the near-surface formations. Table 7.2-1 summarizes the volume of backfill material used during construction.

Operationally, well construction proceeded smoothly, 12 h/d, 7 d/wk, from October 14 to October 20 and November 3 to November 10, and 24 h/d, 7 d/wk, from October 21 to November 2, 2014.

8.0 POST-INSTALLATION ACTIVITIES

Following well installation at R-63i, the well was developed, the wellhead and surface pad were constructed, and a geodetic survey was performed. An aquifer test was not conducted, and a dedicated sampling system was not installed. Site restoration activities will be completed following the final disposition of contained drill cuttings and groundwater, per the NMED-approved waste-disposal decision trees.

8.1 Well Development

The well was developed between November 11, 2014, and January 24, 2015. DTW before well development was 1175.9 ft bgs, 13.1 ft above the bottom of the well screen. The upper 53.4 ft of the well screen was dry before development. Initially, the submerged section of the screened interval was bailed and swabbed to remove formation fines in the filter pack and well sump. The well was bailed dry multiple times and allowed to recharge overnight. Bailing continued until November 17 and resumed between December 5 and December 8, but the water level remained within 5 ft of the bottom of the screened interval.

From January 21 to 23, 2015, municipal water was added incrementally to the well to bring the water level above the top of the screened interval for further development. Each time water was added, the screened interval was swabbed for 1 h and water levels were measured to determine if the screen was still submerged. Turbidity, temperature, pH, dissolved oxygen (DO), oxidation-reduction potential (ORP), and specific conductance were measured at the end of bailing activities. Measured parameters are presented in Appendix B. The well was bailed dry on January 24 and water levels were measured until February 25 to determine if further development had increased the productivity of the well. The final water level recorded on February 25 was 1182.9 ft bgs.

The swabbing tool employed was a 4.5-in. O.D., 1-in.-thick nylon disc attached to a weighted steel rod. The wireline conveyed tool was drawn repeatedly across the screened interval causing a surging action across the screen and filter pack. The bailing tool was a 4.0-in. O.D. by 21.0-ft-long carbon-steel bailer with a total capacity of 12 gal. The tool was repeatedly lowered by wireline, filled, withdrawn from the well, and emptied into the cuttings pit. Approximately 460.5 gal. of groundwater were removed during bailing activities.

From April 20 to 24, 2015, a 3.0-in. I.D. polyvinyl chloride bailer was used to collect groundwater samples, field parameters, and recovery data. Measured parameters are presented in Appendix B. An additional 21.2 gal. of groundwater was removed after well development activities.

Total Volumes of Water Introduced and Purged

During drilling, approximately 4800 gal. of potable water were added between 1115.5 and 1194.1 ft bgs. Approximately 9560 gal. was added during installation of the screened interval filter pack and fine-sand collar (1115.5 to 1194.1 ft bgs). An additional 999 gal. was added during well development. In total, approximately 15,359 gal. of potable water was introduced to the borehole within the perched-intermediate aquifer during project activities.

Approximately 481.7 gal. of groundwater were bailed at R-63i during and after well development activities.

8.1.1 Well Development Field Parameters

During and after well development activities, turbidity, temperature, pH, DO, ORP, and specific conductance were measured.

Field parameters were measured by collecting aliquots of groundwater from the bailers. The final parameters after well development were pH of 6.0, temperature of 11.84ºC, specific conductance of 262 µS/cm, and turbidity of 154.6 nephelometric turbidity units (NTU). Pumping to increase stability of parameters was not performed because of the low productivity of the screened interval. Table B-2.3-1 in Appendix B shows field parameters and volumes bailed during and after well development.

8.2 Aquifer Testing

An aquifer pumping test was not conducted at R-63i because of the low groundwater productivity within the screened interval.

8.3 Dedicated Sampling System Installation

A dedicated sampling system for R-63i was not installed because of low groundwater productivity. The as-built diagram with borehole lithology and technical well completion details for monitoring well R-63i is presented in Figure 8.3-1a. Figure 8.3-1b presents technical notes for the well.

8.4 Wellhead Completion

A reinforced concrete surface pad, 10 ft × 10 ft × 10 in. thick, was installed at the R-63i wellhead. The concrete pad was slightly elevated above the ground surface and crowned to promote runoff. The pad will provide long-term structural integrity for the well. A brass survey pin was embedded in the northwest corner of the pad. A 16-in.-O.D. steel protective casing with a locking lid was installed around the stainless-steel well riser. A total of four bollards, painted yellow for visibility, were set at the outside edges of the pad to protect the well from traffic. All four bollards are designed for easy removal to allow access to the well. Details of the wellhead completion are presented in Figure 8.3-1a.

8.5 Geodetic Survey

A New Mexico licensed professional land surveyor conducted a geodetic survey on January 9, 2014 (Table 8.5-1). The survey data conform to Laboratory Information Architecture project standards IA-CB02, “GIS Horizontal Spatial Reference System,” and IA-D802, “Geospatial Positioning Accuracy Standard for A/E/C and Facility Management.” All coordinates are expressed relative to the New Mexico State Plane Coordinate System Central Zone (NAD 83); elevation is expressed in feet above mean sea level (amsl) using the National Geodetic Vertical Datum of 1929. Survey points include ground surface elevation near the concrete pad, the top of the brass pin in the concrete pad, the top of the well casing, and the top of the protective casing for the R-63i monitoring well.

8.6 Waste Management and Site Restoration

Waste generated from the R-63i project included drilling fluids, purged groundwater (i.e., development water), drill cuttings, decontamination water, and contact waste. A summary of the waste characterization samples collected during drilling, well construction and development of the R-63i well is presented in Table 8.6-1.

All waste streams produced during drilling and development activities were sampled in accordance with “Waste Characterization Strategy Form for R-47, R-58, R-63i, CdV-9-1i” (LANL 2013, 244887) .

Fluids produced during drilling and well development are expected to be land-applied after a review of associated analytical results per the waste characterization strategy form (WCSF) and the ENV-RCRA-QP-010.2, Land Application of Groundwater. If it is determined the drilling fluids are nonhazardous but cannot meet the criteria for land application, they will be evaluated for treatment and disposal at one of the Laboratory’s wastewater treatment facilities. If analytical data indicate that the drilling fluids are hazardous/nonradioactive or mixed low-level waste, the drilling fluids will be disposed of at an authorized facility or one of the Laboratory’s on-site wastewater treatment facilities.

Cuttings produced during drilling are anticipated to be land-applied after a review of associated analytical results per the WCSF and ENV-RCRA-QP-011.2, Land Application of Drill Cuttings. If the drill cuttings do not meet the criteria for land application, they will be disposed of at an authorized facility.

Decontamination fluid used for cleaning equipment is containerized. The fluid waste was sampled and will be disposed of at an authorized facility. The polyethylene liner will be disposed of as industrial waste. Characterization of contact waste will be based upon acceptable knowledge, pending analyses of the waste samples collected from the drill cuttings, purge/development water, and decontamination fluid.

Site restoration activities will include removing drilling fluids and cuttings from the pit and managing the fluids and cuttings as described above, removing the polyethylene liner, removing the containment area berms, backfilling with clean fill, and regrading the containment area, as appropriate.

9.0 DEVIATIONS FROM PLANNED ACTIVITIES

Drilling and well construction at R-63i were performed as specified in "Drilling Plan for Intermediate Aquifer Well R-63i," (LANL 2013, 235924). Well development was performed with a surge block and bailer. Development pumping, aquifer testing, and installation of a dedicated sampling system were not conducted because of the low productivity of the screened interval.

10.0 ACKNOWLEDGMENTS

Boart Longyear drilled and installed the R-63i monitoring well.

TerranearPMC provided oversight on all preparatory and field-related activities.

11.0 REFERENCES AND MAP DATA SOURCES

11.1 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.

LANL (Los Alamos National Laboratory), March 2006. "Storm Water Pollution Prevention Plan for SWMUs and AOCs (Sites) and Storm Water Monitoring Plan," Los Alamos National Laboratory document LA-UR-06-1840, Los Alamos, New Mexico. (LANL 2006, 092600)

LANL (Los Alamos National Laboratory), February 2013. "Drilling Work Plan for Well R-63i," Los Alamos National Laboratory document LA-UR-13-20150, Los Alamos, New Mexico. (LANL 2013, 235924)

LANL (Los Alamos National Laboratory), July 10, 2013. "Waste Characterization Strategy Form for R-47, R-58, R-63i, CdV-9-1i," Los Alamos National Laboratory, Los Alamos, New Mexico. (LANL 2013, 244887)

LANL (Los Alamos National Laboratory), May 2014. "Interim Facility-Wide Groundwater Monitoring Plan for the 2015 Monitoring Year, October 2014–September 2015," Los Alamos National Laboratory document LA-UR-14-23327, Los Alamos, New Mexico. (LANL 2014, 256728)

NMED (New Mexico Environment Department), January 14, 2015. "Approval with Modifications, Interim Facility-Wide Groundwater Monitoring Plan for the 2015 Monitoring Year, October 2014 – September 2015," New Mexico Environment Department letter to P. Maggiore (DOE-NA-LA) and M. Brandt (LANL) from J.E. Kieling (NMED-HWB), Santa Fe, New Mexico. (NMED 2015, 600154)

TerranearPMC, September 2013. "Field Implementation Plan for Intermediate Well R-63i," plan prepared for Los Alamos National Laboratory, Los Alamos, New Mexico. (TerranearPMC 2013, 524579)

TerranearPMC, June 2, 2014. "IWD for Drilling and Installation of LANL Wells R-63i, R-47, and CdV-9-1i," prepared for Los Alamos National Laboratory, Los Alamos, New Mexico. (TerranearPMC 2014, 262889)

11.2 Map Data Sources

Point Feature Locations of the Environmental Restoration Project Database; Los Alamos National Laboratory, Waste and Environmental Services Division, EP2008-0109; 12 April 2010.

Hypsography, 100 and 20 Foot Contour Interval; Los Alamos National Laboratory, ENV Environmental Remediation and Surveillance Program; 1991.

Surface Drainages, 1991; Los Alamos National Laboratory, ENV Environmental Remediation and Surveillance Program, ER2002-0591; 1:24,000 Scale Data; Unknown publication date.

Paved Road Arcs; Los Alamos National Laboratory, KSL Site Support Services, Planning, Locating and Mapping Section; 06 January 2004; as published 28 May 2009.

Dirt Road Arcs; Los Alamos National Laboratory, KSL Site Support Services, Planning, Locating and Mapping Section; 06 January 2004; as published 28 May 2009.

Structures; Los Alamos National Laboratory, KSL Site Support Services, Planning, Locating and Mapping Section; 06 January 2004; as published 28 May 2009.

Technical Area Boundaries; Los Alamos National Laboratory, Site Planning & Project Initiation Group, Infrastructure Planning Division; 4 December 2009.

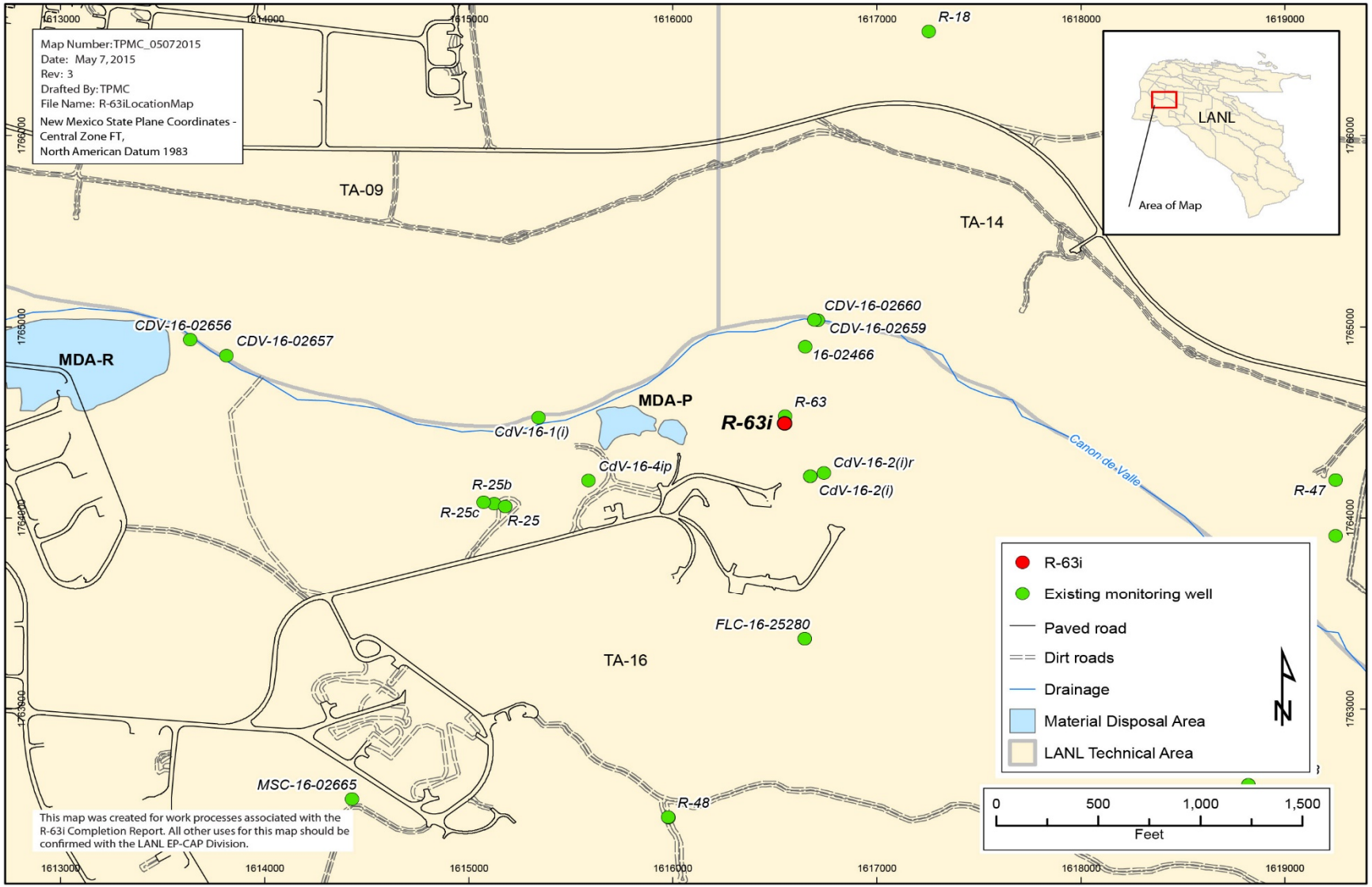


Figure 1.0-1 Location of monitoring well R-63i

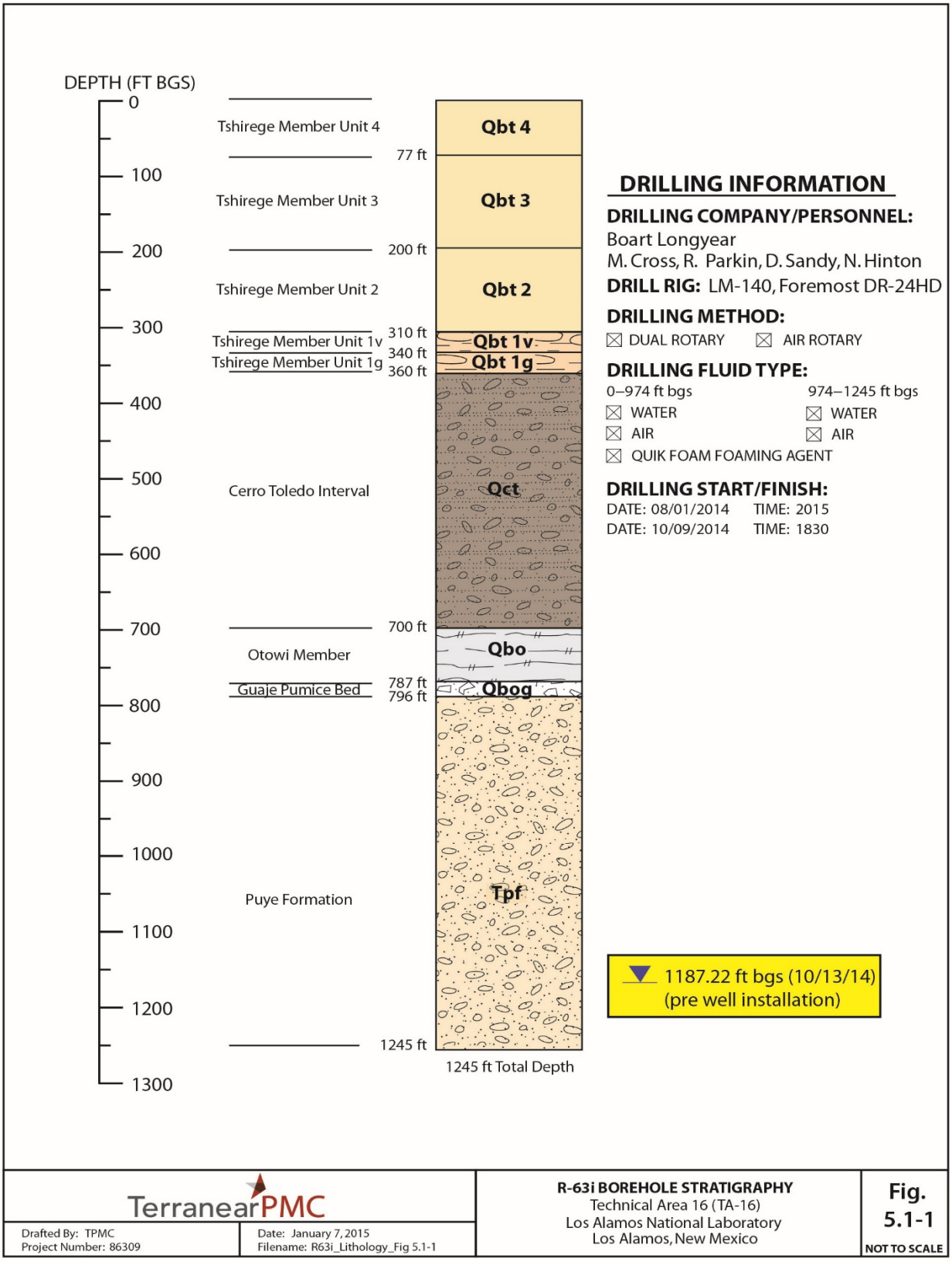


Figure 5.1-1 Monitoring well R-63i borehole stratigraphy

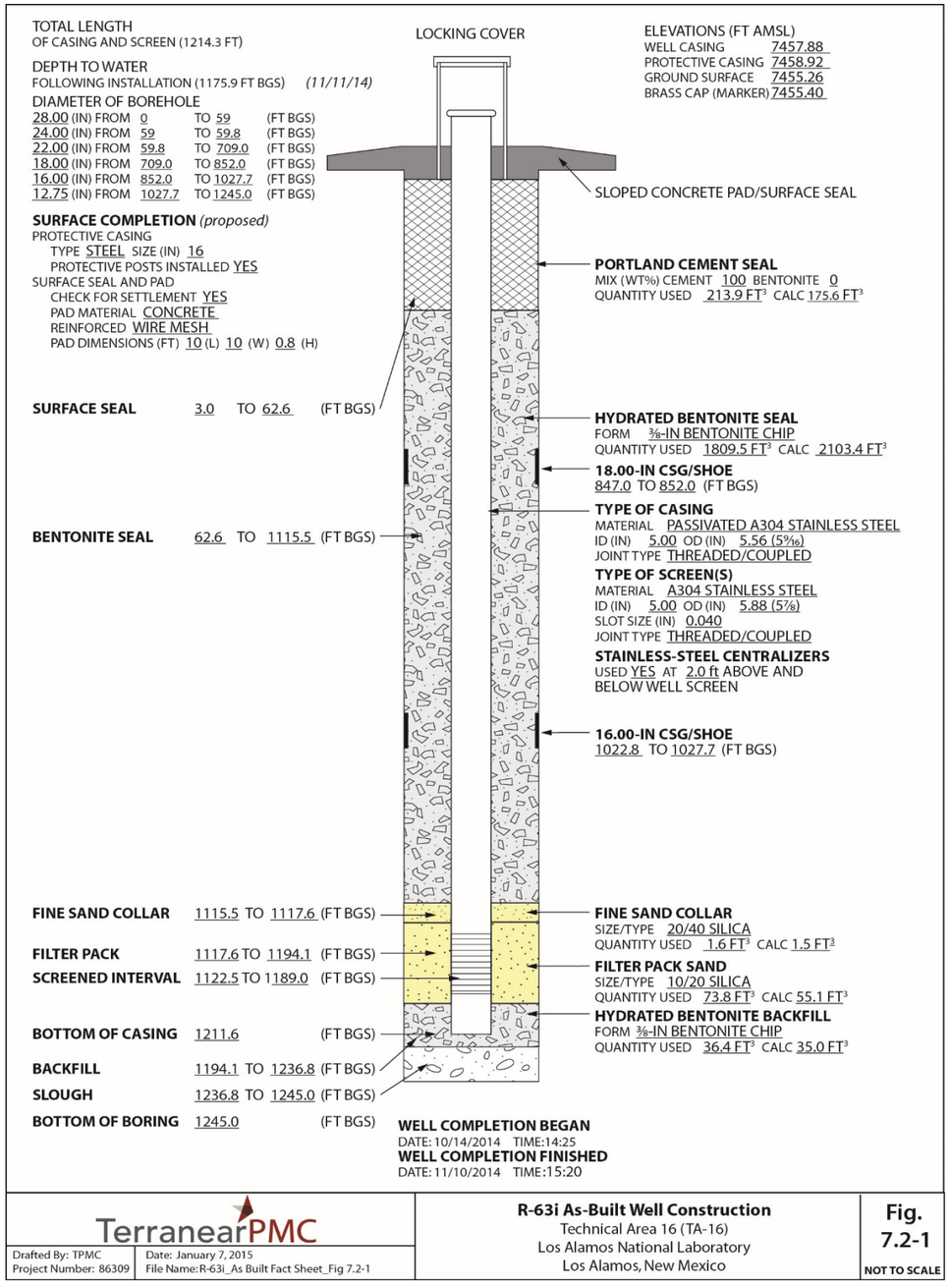
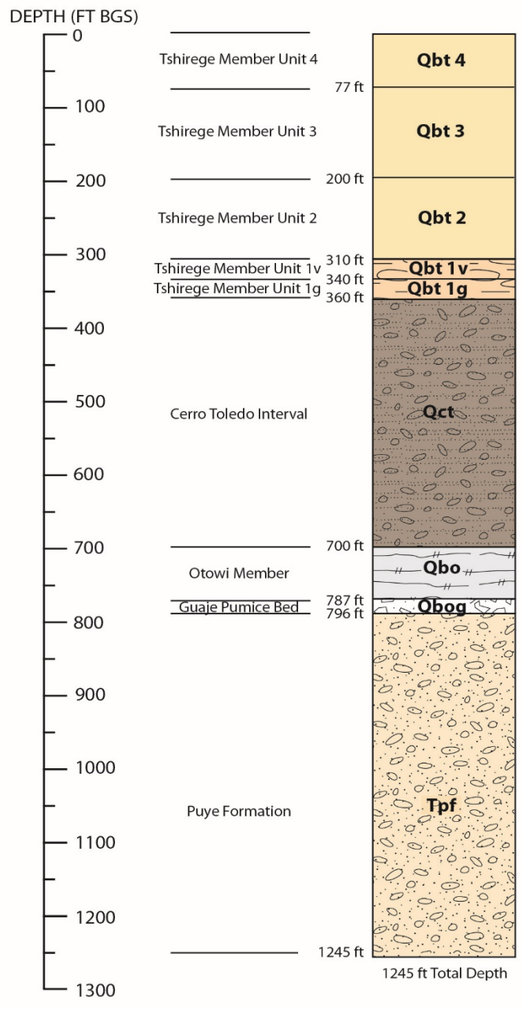
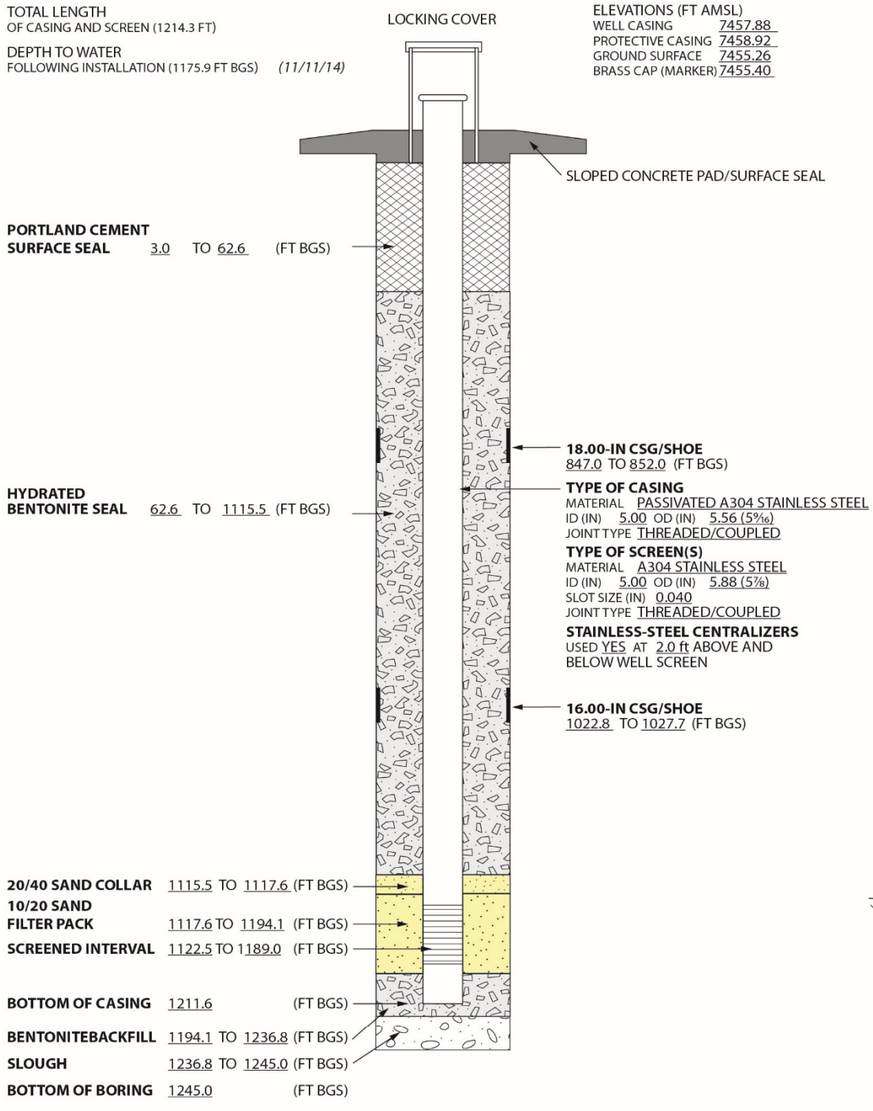


Figure 7.2-1 Monitoring well R-63i as-built well construction diagram

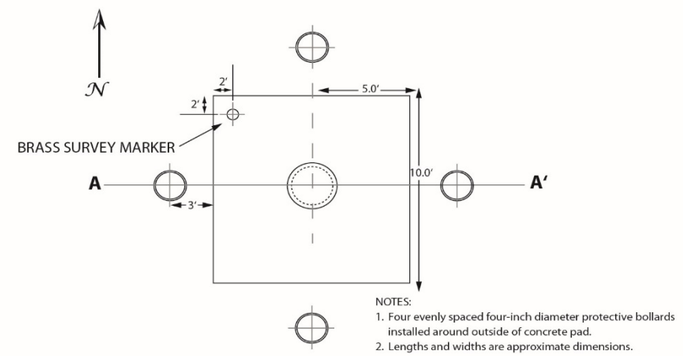
★ **SEE FIGURE 8.3-1b FOR R-63i TECHNICAL NOTES**



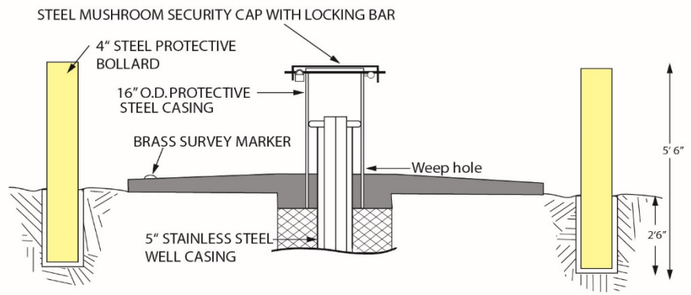
BOREHOLE LITHOLOGY



WELL COMPLETION DETAILS



PLAN VIEW-SURFACE COMPLETION



WELL HEAD DETAILS
SECTION A-A'

TerranearPMC		**MONITORING WELL R-63i AS-BUILT WELL DIAGRAM** Technical Area 16 (TA-16) Los Alamos National Laboratory Los Alamos, New Mexico	Figure 8.3-1a NOT TO SCALE
Drafted By: TPMC	Date: January 7, 2015		
Project Number: 86309	Filename: R63i_Char...Fig8.3-1a		

Figure 8.3-1a Monitoring well R-63i as-built diagram with borehole lithology and technical well completion details

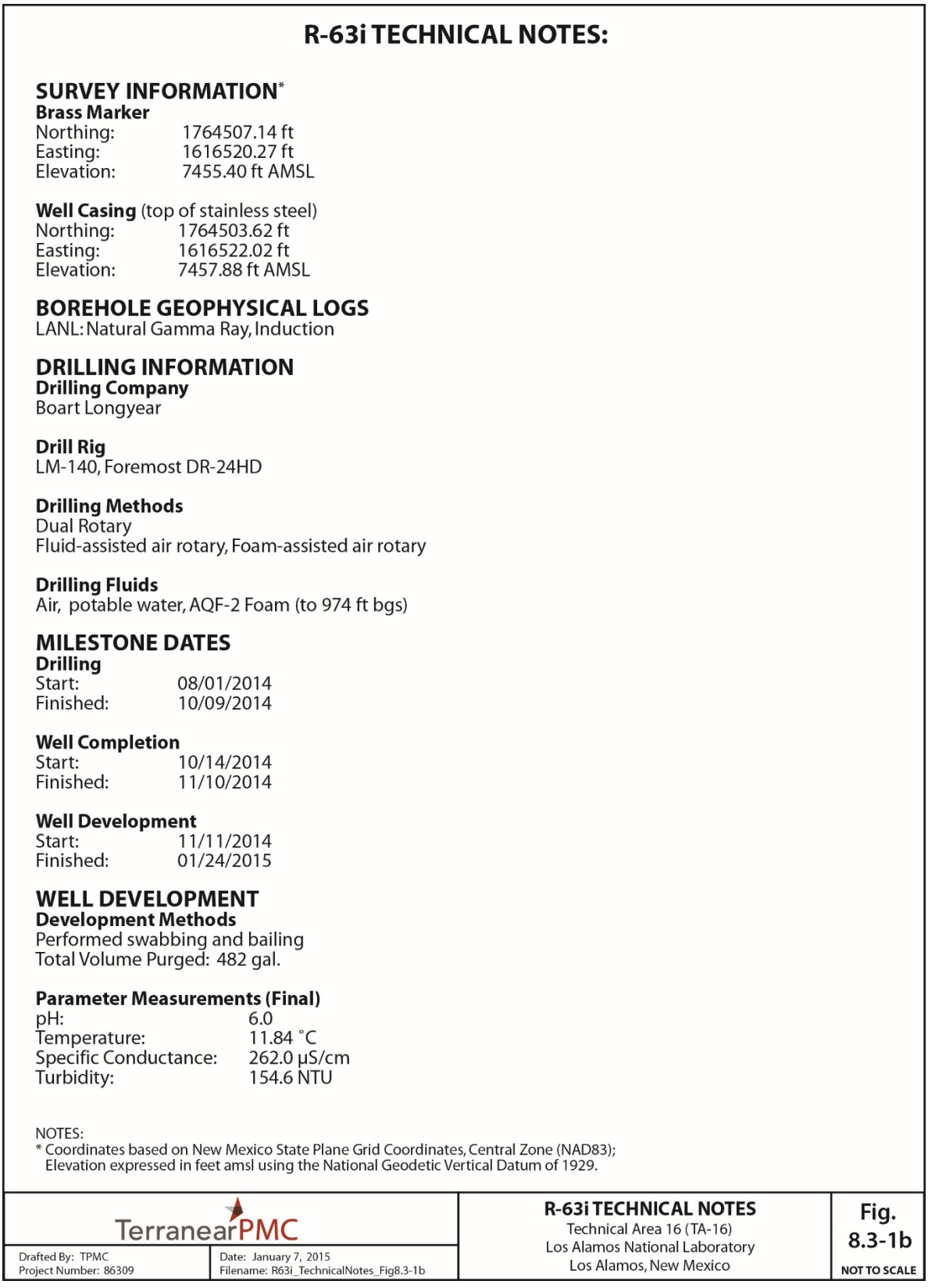


Figure 8.3-1b As-built technical notes for monitoring well R-63i

Table 3.1-1
Fluid Quantities Used during R-63i Drilling, Well Construction, and Well Development

Date	Depth Interval (ft bgs)	Water (gal.)	Cumulative Water (gal.)	AQF-2 Foam (gal.)	Cumulative AQF-2 Foam (gal.)
Drilling					
8/02/14	0-205	3510	3510	17	17
8/03/14	205-687	13500	17,010	83.5	100.5
8/04/14	687-709	900	17,910	6	106.5
9/14/14	709-727	7350	25,260	0	106.5
9/15/14	727-734	300	25,560	0	106.5
9/16/14	734-814	0	25,560	0	106.5
9/17/14	814-852	900	26,460	0	106.5
9/18/14	852-852	1900	28,360	7	113.5
9/19/14	852-852	1500	29,860	4	117.5
9/20/14	852-838	6500	36,360	0	117.5
9/23/14	838-904	1875	38,235	2	119.5
9/24/14	904-1025	4250	42,485	4.5	124
9/25/14	1025-1027	4250	46,735	1	125
9/26/14	1027-1027	1500	48,235	0	125
9/27/14	1027-1014	600	48,835	0	125
9/29/14	1014-1057	2100	50,935	0	125
9/30/14	1057-1175	4000	54,935	0	125
10/03/14	1175-1225	800	55,735	0	125
10/07/14	1225-1245	300	56,035	0	125
Well Construction					
10/14/14	1237-1227	200	200	n/a[a]	n/a
10/15/14	1227-1213	2300	2500	n/a	n/a
10/20/14	1213-1209	500	3000	n/a	n/a
10/21/14	1209-1157	5200	8200	n/a	n/a
10/22/14	1157-1140	1310	9510	n/a	n/a
10/23/14	1140-1110	3050	12,560	n/a	n/a
10/24/14	1110-1026	7830	20,390	n/a	n/a
10/27/14	1026-943	11,325	31,715	n/a	n/a
10/28/14	943-857	14,260	45,975	n/a	n/a
11/1/14	857-813	770	46,745	n/a	n/a
11/2/14	813-681	2850	49,595	n/a	n/a
11/3/14	681-596	2040	51,635	n/a	n/a
11/4/14	596-472	2880	54,515	n/a	n/a
11/5/14	472-378	2800	57,315	n/a	n/a

Table 3.1-1 (continued)

Date	Depth Interval (ft bgs)	Water (gal.)	Cumulative Water (gal.)	AQF-2 Foam (gal.)	Cumulative AQF-2 Foam (gal.)
Well Construction (cont.)					
11/6/14	378-217	2580	59,895	n/a	n/a
11/7/14	217-63	2020	61,915	n/a	n/a
11/9/14	63-36	450	62,365	n/a	n/a
11/10/14	36-3	510	62,875	n/a	n/a
Well Development					
1/21/15	1115.5-1194.1[b]	749	749	n/a	n/a
1/22/15	1115.5-1194.1[b]	126	875	n/a	n/a
1/23/15	1115.5-1194.1[b]	124	999	n/a	n/a
Total Water Volume (gal.)					
R-63i	119,909				

[a] n/a = Not applicable. Foam use was terminated at 974 ft bgs during drilling, except for a small amount used at 1025 ft bgs to lift cuttings and help clean out the cased borehole; none was used during well construction.

[b] Top of fine-sand collar to bottom of filter pack.

Table 4.2-1
Summary of Groundwater Screening Samples
Collected during Drilling and Well Development of Well R-63i

Location ID	Sample ID	Date Collected	Collection Depth (ft bgs)	Sample Type	Analysis
Drilling					
R-63i	CACV-14-85704	9/16/14; 2110 h	775	Groundwater, Air lifted	RDX
R-63i	CACV-14-85705	9/23/14; 2258 h	864	Groundwater, Air lifted	RDX
R-63i	CACV-14-85706	9/25/14; 0510 h	1025	Groundwater, Air lifted	RDX
R-63i	CACV-14-85707	10/1/14; 0545 h	1175	Groundwater, Air lifted	RDX
R-63i	CACV-14-85708	10/3/14; 1215 h	1175	Groundwater, Air lifted	RDX
R-63i	CACV-14-85709	10/3/14; 1410 h	1185	Groundwater, Air lifted	RDX
R-63i	CACV-14-85710	10/3/14; 1545 h	1205	Groundwater, Air lifted	RDX
R-63i	CACV-14-85711	10/3/14; 1737 h	1225	Groundwater, Air lifted	RDX
R-63i	CACV-15-95835	4/22/15; 1305 h	1185	Groundwater, Bailed	RDX, TOC, anions, metals
R-63i	CACV-15-95836	4/24/15; 1215 h	1186	Groundwater, Bailed	RDX, TOC, anions, metals

Table 7.2-1
R-63i Monitoring Well Annular Fill Materials

Material	Volume
Upper surface seal: cement slurry	213.9 ft^3
Upper bentonite seal: bentonite chips	1809.5 ft^3
Fine-sand collar: 20/40 silica sand	1.6 ft^3
Filter pack: 10/20 silica sand	73.8 ft^3
Backfill: bentonite chips	36.4 ft^3

Table 8.5-1
R-63i Survey Coordinates

Identification	Northing	Easting	Elevation
R-63i brass cap embedded in pad	1764507.14	1616520.27	7455.40
R-63i ground surface near pad	1764509.76	1616518.75	7455.26
R-63i top of stainless-steel well casing	1764503.62	1616522.02	7457.88
R-63i top of 16-in. protective casing	1764504.06	1616522.07	7458.92

Note: All coordinates are expressed as New Mexico State Plane Coordinate System Central Zone (NAD 83); elevation is expressed in ft amsl using the National Geodetic Vertical Datum of 1929.

Table 8.6-1
Summary of Waste Samples Collected during
Drilling, Development, and Installation of Sampling System at R-63i

Location ID	Sample ID	Date Collected	Description	Sample Type
R-63i	WST16-14-86628	12/9/14	Drill fluids (unfiltered sample)	Liquid
R-63i	WST16-14-86629	12/9/14	Drill fluids (filtered sample)	Liquid
R-63i	WST16-14-86630	12/9/14	Drill fluids (field duplicate)	Liquid
R-63i	WST16-14-86631	12/9/14	Drill fluids (field trip blank)	Liquid
R-63i	WST16-14-86663 changed to WST16-15-97332	4/30/15	Drill cuttings (waste sample)	Solids
R-63i	WST16-14-86664 changed to WST16-15-97333	4/30/15	Drill cuttings (field trip blank)	Solids
R-63i	WST16-15-97392	5/13/15	Decon fluid (filtered sample)	Liquid
R-63i	WST16-15-97393	5/13/15	Decon fluid (unfiltered sample)	Liquid
R-63i	WST16-15-97394	5/13/15	Decon fluid (field duplicate)	Liquid
R-63i	WST16-15-97395	5/13/15	Decon fluid (field trip blank)	Liquid
R-63i	WST16-15-97388	5/13/15	Development water (filtered sample)	Liquid
R-63i	WST16-15-97389	5/13/15	Development water (unfiltered sample)	Liquid
R-63i	WST16-15-97390	5/13/15	Development water (field duplicate)	Liquid
R-63i	WST16-15-97391	5/13/15	Development water (field trip blank)	Liquid

Appendix A

Borehole R-63i Lithologic Log

BOREHOLE IDENTIFICATION (ID): R-63i	**TECHNICAL AREA (TA):** 16	
DRILLING COMPANY: Boart Longyear Company	**START DATE/TIME:** 8/1/14; 2015	**END DATE/TIME:** 10/09/14; 1830
DRILLING METHOD: Rotary and Dual Rotary	**MACHINE**: LM140 and Foremost DR24 HD	**SAMPLING METHOD:** Grab
GROUND ELEVATION: 7455.26 ft amsl		**TOTAL DEPTH:** 1245 ft
DRILLERS: M. Cross, R. Parkin, D. Sandy	**SITE GEOLOGISTS:** T. Naibert, T. Sower, J. Jordan, D. Legett	

DEPTH (ft bgs)	LITHOLOGY	LITHOLOGIC SYMBOL	NOTES
0–5	**UNIT 4 OF THE TSHIREGE MEMBER OF THE BANDELIER TUFF:** Rhyolitic Tuff—very pale orange (10YR 8/2) to orange-brown (10YR 7/4) poorly welded, crystal- and lithic-rich tuff. 0–5 ft WR: 75% powdered ash-flow tuff and welded tuff fragments; 20% rhyolitic and dacitic lithic clasts; 5% quartz and sanidine crystals. +10F: 80% dacitic and rhyolitic lithic clasts; 15% crystal-bearing ash flow tuff fragments; 5% quartzite chips (likely from pad construction). +35F: 50% tuff fragments; 40% dacitic lithic clasts; 10% quartz and sanidine crystals.	Qbt 4	Note: Drill cuttings for descriptive analysis were collected at 5-ft intervals from ground surface to borehole total depth at 1245 ft bgs. Unit 4 of the Tshirege Member of the Bandelier Tuff (Qbt 4) encountered from 0–77 ft bgs is 77 ft thick.
5–55	Rhyolitic Tuff—pale brown-orange (5YR 8/2) to grayish pink-orange (10R 7/4) poorly to moderately welded, crystal- and lithic-rich tuff. 5–55 ft WR: 85% powdered ash-flow tuff and welded tuff fragments; 10% rhyolitic and dacitic lithic clasts; 5% quartz and sanidine crystals. +10F: 70–95% crystal-bearing ash-flow tuff fragments; 5–30% dacitic and rhyolitic lithic clasts. +35F: 40–60% tuff fragments; 35–55% quartz and sanidine crystals; 5–20% dacitic lithic clasts.	Qbt 4	
55–60	Rhyolitic Tuff—pale brown-orange (5YR 8/2) to grayish pink-orange (10R 7/4) poorly to moderately welded, crystal- and lithic-rich tuff. 55–60 ft WR: 85% powdered ash-flow tuff and welded tuff fragments; 10% rhyolitic and dacitic lithic clasts; 5% quartz and sanidine crystals. +10F: 70–95% crystal-bearing ash-flow tuff fragments; 5–30% dacitic and rhyolitic lithic clasts. +35F: 45–65% quartz and sanidine crystals; 30–50% tuff fragments; 5–20% dacitic lithic clasts.	Qbt 4	

DEPTH (ft bgs)	LITHOLOGY	LITHOLOGIC SYMBOL	NOTES
60–70	Rhyolitic Tuff—light gray (N7) to pale pink-orange (10R 7/1) poorly welded, crystal- and lithic-rich tuff. 60–77 ft WR/+10F: 50–70% quartz and sanidine crystals; 30–40% tuff fragments; <10% gray rhyolitic and dacitic lithic clasts. +35F: 80–95% quartz and sanidine crystals; 5–20% tuff fragments; <5% dacitic lithic clasts.	Qbt 4	
70–77	Rhyolitic Tuff—light gray (N7) to pale pink-orange (10R 7/1) poorly welded, crystal- and lithic-rich tuff. 60–77 ft WR/+10F: 30–70% quartz and sanidine crystals; 20–60% tuff fragments; <10% gray rhyolitic and dacitic lithic clasts. +35F: 70–90% quartz and sanidine crystals; 10–30% tuff fragments; <5% dacitic lithic clasts.	Qbt 4	The Qbt 3t/Qbt 3 contact, estimated at 77 ft bgs, is based on natural gamma logging
77–95	**UNIT 3 OF THE TSHIREGE MEMBER OF THE BANDELIER TUFF:** Rhyolitic Tuff—light gray (N7) to pale pink-orange (10R 7/1) poorly welded, crystal- and lithic-rich tuff. 77–95 ft WR/+10F: 40–70% tuff fragments; 30–60% quartz and sanidine crystals; <10% gray rhyolitic and dacitic lithic clasts. +35F: 80–95% quartz and sanidine crystals; 5–20% tuff fragments; <5% dacitic lithic clasts.	Qbt 3	Unit 3 of the Tshirege Member of the Bandelier Tuff (Qbt 3), encountered from 77–200 ft bgs, is approximately 123 ft thick.
95–125	Rhyolitic Tuff—light gray (N7) to pale pink-orange (10R 7/1) poorly welded, crystal- and lithic-rich tuff. 95–125 ft WR/+10F: 60–80% tuff fragments; 20–40% quartz and sanidine crystals; <10% gray rhyolitic and dacitic lithic clasts. +35F: 80–95% quartz and sanidine crystals; 5–20% tuff fragments; <5% dacitic lithic clasts.	Qbt 3	
125–145	Rhyolitic Tuff—light gray (N7) to pale pink-orange (10R 7/1) poorly welded, crystal-rich tuff. 125–145 ft WR: 40–70% tuff fragments; 30–60% quartz and sanidine crystals; <5% gray rhyolitic and dacitic lithic clasts. +10F: 60–80% tuff fragments; 20–40% quartz and sanidine crystals; <5% gray rhyolitic and dacitic lithic clasts. +35F: 80–90% quartz and sanidine crystals; 10–20% tuff fragments; <5% dacitic lithic clasts	Qbt 3	

DEPTH (ft bgs)	LITHOLOGY	LITHOLOGIC SYMBOL	NOTES
145–185	Rhyolitic Tuff—light gray (N7) to pale pink-orange (10R 7/1) very poorly welded, crystal-rich tuff. 145–185 ft WR: 50–70% quartz and sanidine crystals; 30–50% tuff fragments. +10F: 50–60% tuff fragments; 40–50% quartz and sanidine crystals. +35F: 95–98% quartz and sanidine crystals; 2–5% tuff fragments.	Qbt 3	
185–200	Rhyolitic Tuff—light gray (N7) to pale pink-orange (10R 7/1) very poorly welded, crystal-rich tuff. 185–200 ft WR: 50–70% quartz and sanidine crystals; 30–50% tuff fragments. +10F: 50–60% tuff fragments; 40–50% quartz and sanidine crystals. +35F: 95–98% quartz and sanidine crystals; 2–5% tuff fragments.	Qbt 3	**Note:** Site geologist recorded slowing of penetration rate in this interval compared with above. The Qbt 3/Qbt 2 contact estimated at 200 ft bgs is based on abrupt slowing of penetration rate during drilling.
200–205	**UNIT 2 OF THE TSHIREGE MEMBER OF THE BANDELIER TUFF** Rhyolitic Tuff—gray (N6) to brown (5YR 6/1), strongly welded, crystal-bearing tuff. 200–205 ft WR: 60–80% welded tuff fragments; 20–40% quartz and sanidine crystals. +10F: 75–85% welded tuff fragments; 15–25% euhedral quartz crystals. +35F: 50–70% rhyolitic tuff fragments; 30–50% quartz and sanidine crystals.	Qbt 2	Unit 2 of the Tshirege Member of the Bandelier Tuff (Qbt 2), encountered from 200 to 310 ft bgs, is approximately 110 ft thick.
205–235	Rhyolitic Tuff—gray (N6) to pale reddish-brown (10R 7/2), strongly welded, crystal-bearing tuff. 205–235 ft WR: 80% tuff fragments; 20% quartz and sanidine crystals. +10F: 90% crystal-bearing tuff fragments; 10% euhedral quartz and sanidine crystals. +35F: 70–80% welded tuff fragments; 20–30% quartz and sanidine crystals.	Qbt 2	
235–280	Rhyolitic Tuff—gray (N6) to pale reddish-brown (10R 7/2), strongly welded, crystal-rich tuff. 235–280 ft WR: 70–90% tuff fragments; 10–30% quartz and sanidine crystals. +10F: 80–90% crystal-bearing tuff fragments; 10–20% euhedral quartz and sanidine crystals. +35F: 50–80% welded tuff fragments; 20–50% quartz and sanidine crystals.	Qbt 2	Note: Percentage of quartz phenocrysts increases down section, especially in the +35 sieve fraction.

DEPTH (ft bgs)	LITHOLOGY	LITHOLOGIC SYMBOL	NOTES
280–290	Rhyolitic Tuff—gray (N6) to pale reddish-brown (10R 7/2), moderately welded, crystal-rich tuff 280–290 ft WR: 70–90% tuff fragments; 10–30% quartz and sanidine crystals. +10F: 80–90% crystal-bearing tuff fragments; 10–20% euhedral quartz and sanidine crystals. +35F: 50–80% quartz and sanidine crystals; 20–50% welded tuff fragments.	Qbt 2	
290–310	Rhyolitic Tuff—gray (N6) to pale reddish-brown (10R 7/2), moderately welded, crystal-rich tuff 290–310 ft WR: 70–80% tuff fragments; 20–30% quartz and sanidine crystals. +10F: 70–80% crystal-bearing tuff fragments; 20–30% euhedral quartz and sanidine crystals. +35F: 70–90% quartz and sanidine crystals; 5–30% welded tuff fragments; <5% white to orange devitrified pumice clasts.	Qbt 2	The Qbt 2/Qbt 1v contact estimated at 310 ft bgs is based on natural gamma logging and increase in crystals in cuttings.
310–340	**UNIT 1v OF THE TSHIREGE MEMBER OF THE BANDELIER TUFF** Rhyolitic Tuff—light gray (N7) to pale orange (10YR 8/2), poorly welded, crystal-rich tuff, with abundant light gray (N7) dacitic lithics. 305–340 ft WR: 50–60% light gray lithic fragments; 10–20% crystal-rich tuff fragments; 30–40% quartz and sanidine crystals. +10F: 70–80% light gray dacite lithic fragments; 10–20% pale orange crystal-rich tuff fragments; 10–20% euhedral quartz and sanidine crystals. +35F: 85–95% quartz and sanidine crystals; 5–10% dacite lithics; <5% tuff fragments; trace devitrified pumice.	Qbt 1v	Unit 1v of the Tshirege Member of the Bandelier Tuff (Qbt 1v) encountered from 310–340 ft bgs is approximately 30 ft thick. The Qbt 1v/Qbt 1g contact estimated at 340 ft bgs is based on presence of glassy pumice fragments in tuff cuttings below contact.
340–350	**UNIT 1g OF THE TSHIREGE MEMBER OF THE BANDELIER TUFF** Rhyolitic Tuff—light gray (N7) to pale orange (10YR 8/2), poorly welded, crystal-rich tuff, with abundant light gray (N7) rhyolitic and dacitic lithics. 340–350 ft WR: 50–60% light gray lithic fragments; 20–30% crystal-rich tuff fragments; 20–30% quartz and sanidine crystals. +10F: 70–80% light gray dacite lithic fragments; 10–20% pale orange crystal-rich tuff fragments; 10–20% euhedral quartz and sanidine crystals. +35F: 85–95% quartz and sanidine crystals; 5–10% dacite lithics; <5% tuff fragments; trace glassy, fibrous pumice.	Qbt 1g	Unit 1g of the Tshirege Member of the Bandelier Tuff (Qbt 1g), encountered from 340–360 ft bgs, is approximately 20 ft thick. **Note**: this interval contained minimal cutting returns during drilling.

DEPTH (ft bgs)	LITHOLOGY	LITHOLOGIC SYMBOL	NOTES
350–355	No sample returns	Qbt 1g	
355–360	Rhyolitic Tuff—light gray (N7) to pale orange (10YR 8/2), poorly welded, crystal-rich tuff, with abundant light gray (N7) rhyolitic and dacitic lithics. 340–350 ft WR: 40–60% light gray lithic fragments; 20–30% crystal-rich tuff fragments; 20–30% glassy, fibrous pumice clasts; <10% euhedral quartz crystals. +10F: 60–70% light gray dacite lithic fragments; 10–20% pale orange tuff fragments; 10–20% glassy pumice clasts; <10% euhedral quartz and sanidine crystals. +35F: 60–70% quartz and sanidine crystals; 10–30% rhyolite and dacite lithics; 5–15% tuff fragments; 5–15% glassy, fibrous pumice.	Qbt 1g	The Qbt 1g/Qct contact estimated at 360 ft bgs is based on color change and presence of varied volcaniclastic grains in cuttings.
360–380	**CERRO TOLEDO INTERVAL** Pumiceous Sediments—sand to gravel size angular to subangular white pumice grains with minor quartz, obsidian, and volcaniclastic sediments. 360–380 ft WR/+10F: 60–80% pumice clasts up to 15 mm; 20–40% gray dacite and varicolored rhyolite clasts up to 10 mm; trace obsidian fragments. +35F: 70–90% pumice clasts; 10–20% dacite and rhyolite grains; <10% angular quartz grains; trace obsidian fragments.	Qct	The Cerro Toledo interval (Qct) encountered from 360 to 700 ft bgs is approximately 340 ft thick.
380–400	Pumiceous Sediments—sand to gravel size angular to subangular white pumice grains with minor quartz, obsidian, and volcaniclastic sediments. 380–400 ft WR/+10F: 60–80% pumice clasts up to 10 mm; 20–40% gray dacite and varicolored rhyolite clasts up to 6 mm; trace quartz grains. +35F: 85–95% pumice clasts; 10% dacite and rhyolite grains; <10% angular quartz grains; trace obsidian fragments.	Qct	

DEPTH (ft bgs)	LITHOLOGY	LITHOLOGIC SYMBOL	NOTES
400–415	Pumiceous Sediments—sand to gravel size angular to subangular white pumice grains with minor quartz, obsidian, and volcaniclastic sediments. 400–415 ft WR/+10F: 80–90% pumice clasts up to 10 mm; 10–20% gray dacite and varicolored rhyolite clasts up to 6 mm; <5% quartz grains. +35F: 40–70% angular euhedral quartz grains 30–50% pumice clasts; <10% dacite and rhyolite grains.	Qct	
415–455	Pumiceous Sediments—sand to gravel size angular to subangular orange-brown (5YR 7/4) pumice grains with minor quartz and volcaniclastic sediments. 415–455 ft WR/+10F: 70–80% pumice clasts up to 20 mm; 20–30% gray dacite and varicolored rhyolite clasts up to 10 mm; trace quartz grains. +35F: 70–80% pumice clasts; 10–20% angular quartz grains; 10–15% dacite and rhyolite grains.	Qct	Note: strong color change from white pumices above to light brown-orange pumices below.
455–460	Pumiceous Sediments—sand to gravel size angular to subangular orange-brown (5YR 7/4) pumice grains with minor quartz and volcaniclastic sediments. 455–460 ft WR/+10F: 90% pumice clasts up to 12 mm; 10% gray dacite and varicolored rhyolite clasts up to 6 mm; trace quartz grains. +35F: 60% angular euhedral quartz grains 30–35% pumice clasts; 5% dacite and rhyolite grains.	Qct	
460–485	Pumiceous Sediments—sand to gravel size angular to subangular orange-brown (5YR 7/4) pumice grains with minor quartz and volcaniclastic sediments. 460–485 ft WR/+10F: 70–80% pumice clasts up to 20 mm; 20–30% gray dacite and varicolored rhyolite clasts up to 10 mm; trace quartz grains. +35F: 60–80% pumice clasts; 10–30% angular quartz grains; 10–15% dacite and rhyolite grains.	Qct	
485–555	Pumiceous Sediments—sand to gravel size angular to subangular orange-brown (5YR 7/4) pumice grains with minor quartz and volcaniclastic sediments. 485–555 ft WR/+10F: 60–80% pumice clasts up to 15 mm; 20–40% gray dacite and varicolored rhyolite clasts up to 10 mm; trace quartz grains. +35F: 60–80% pumice clasts; 10–30% angular quartz grains; 10–30% dacite and rhyolite grains.	Qct	

DEPTH (ft bgs)	LITHOLOGY	LITHOLOGIC SYMBOL	NOTES
555–570	Pumiceous Sediments—sand to gravel size angular to subangular orange-brown (5YR 7/4) pumice grains with various volcaniclastic sediments. 555–570 ft WR/+10F: 50–60% pumice clasts up to 10 mm; 40–50% gray dacite and varicolored rhyolite clasts up to 10 mm; trace quartz grains. +35F: 60–80% pumice clasts; 10–30% dacite and rhyolite grains; <10% angular quartz grains.	Qct	
570–630	Pumiceous Sediments—sand to gravel size angular to subangular light gray-white (N8 to N9) to very pale orange (10YR 8/2) pumice clasts with minor dacite and rhyolite clasts and quartz grains. 570–630 ft WR/+10F: 80–90% white pumice clasts up to 15 mm; 10–20% gray dacite and varicolored rhyolite clasts up to 10 mm; trace quartz grains. +35F: 85–95% white pumice clasts; 5–10% angular quartz grains; <10% dacite and rhyolite grains	Qct	**Note:** below 570 ft, pumices are whiter and less oxidized than above, and volcaniclastic sediments represent a smaller percentage of cuttings samples.
630–670	Pumiceous Sediments—sand to gravel size angular to subangular very pale orange (10YR 8/2) pumice clasts with minor dacite and rhyolite clasts and quartz grains. 630–670 ft WR/+10F: 80–90% pale orange pumice clasts up to 20 mm; 10–20% gray dacite and varicolored rhyolite clasts up to 10 mm; trace quartz grains. +35F: 85–95% white pumice clasts; 5–10% angular quartz grains; <10% dacite and rhyolite grains	Qct	Slightly more orange-brown oxidation of pumices
670–675	Pumiceous Sediments—sand to gravel size angular to subangular very pale orange (10YR 8/2) pumice clasts with minor dacite and rhyolite clasts and quartz grains. 670–675 ft WR/+10F: 90% pumice clasts up to 10 mm; 10% gray dacite and varicolored rhyolite clasts up to 10 mm; trace quartz grains. +35F: 60% pumice clasts 35% euhedral quartz grains; 5% dacite and rhyolite grains.	Qct	

DEPTH (ft bgs)	LITHOLOGY	LITHOLOGIC SYMBOL	NOTES
675–700	Pumiceous Sediments—sand to gravel size angular to subangular very pale orange (10YR 8/2) pumice clasts with minor dacite and rhyolite clasts and quartz grains. 630–670 ft WR/+10F: 80–90% white to pale orange pumice clasts up to 20 mm; 10–20% gray dacite and varicolored rhyolite clasts up to 10 mm; trace quartz grains. +35F: 85–95% white pumice clasts; 5–10% angular quartz grains; <10% dacite and rhyolite grains	Qct	The Qct/Qbo contact, estimated at 700 ft bgs, is based on correlation from well R-63 and pumice color change.
700–715	**OTOWI MEMBER OF THE BANDELIER TUFF** Rhyolitic Tuff—white (N9), poorly welded, pumice- and lithic-rich tuff. 700–715 ft WR/+10F: 40–70% white pumice; 30–50% gray rhyolite lithic fragments; 5–20% quartz grains. +35F: 40–70% white pumice clasts; 10–50% quartz grains; 10–30% lithic fragments.	Qbo	The Otowi Member of the Bandelier Tuff (Qbo), encountered from 700 to 785 ft bgs, is approximately 85 ft thick.
715–720	Rhyolitic Tuff—white (N9), poorly welded, pumice- and lithic-rich tuff. 715–720 ft WR: 40–70% white pumice; 30–50% gray rhyolite lithic fragments; 5–20% quartz grains. +10F/+35F: Insufficient returns to sieve.	Qbo	
720–735	No sample returns.	Qbo	
735–740	Rhyolitic Tuff—white (N9), poorly welded, pumice- and lithic-rich tuff. 735–740 ft WR: 100% white ash from poorly welded ash flow tuff. +10F: No clasts in this size fraction. +35F: 90% white to tan pumice clasts; 10% quartz and sanidine crystals.	Qbo	
740–787	Rhyolitic Tuff—white (N9), poorly welded, pumice- and lithic-rich tuff. 740–787 ft WR: 80–100% white ash from poorly welded ash flow tuff; <20% rounded, tan pumice clasts; trace lithic fragments +10F: 99–100% tan, rounded pumice clasts; trace lithic fragments. Low sieve fraction volume. +35F: 70–100% white to tan pumice clasts; <30% quartz and sanidine crystals.	Qbo	The Qbo/Qbog contact, estimated at 787 ft bgs, is based on increased abundance of pumice in cuttings

DEPTH (ft bgs)	LITHOLOGY	LITHOLOGIC SYMBOL	NOTES
787–796	**GUAJE PUMICE BED OF THE OTOWI MEMBER OF THE BANDELIER TUFF** Rhyolitic Tuff—white (N9), poorly welded, pumice- and lithic-rich tuff. 787–805 ft WR: 50–70% rounded, tan pumice clasts; 30–50% white ash from poorly welded ash flow tuff. +10F: 99–100% tan, rounded pumice clasts; trace lithic fragments. +35F: 99–100% white to tan pumice clasts; trace quartz and sanidine crystals.	Qbog	The Guaje Pumice Bed of the Otowi Member of the Bandelier Tuff (Qbog) encountered from 787–796 ft bgs is approximately 9 ft thick. The Qbog/Tpf contact estimated at 796 ft bgs is based on expected lithology and cuttings from R-63.
796–805	**PUYE FORMATION** Rhyolitic Tuff—white (N9), poorly welded, pumice- and lithic-rich tuff. 796–805 ft WR: 50–70% rounded, tan pumice clasts; 30–50% white ash from poorly welded ash flow tuff. +10F: 99–100% tan, rounded pumice clasts; trace lithic fragments. +35F: 99–100% white to tan pumice clasts; trace quartz and sanidine crystals.	Tpf	The Puye Formation (Tpf) encountered from 796–1245 ft bgs is at least 449 ft thick. **Note:** This interval is similar to the 785–796 ft bgs interval and probably represents cuttings from above.
805–815	No sample returns.	Tpf	
815–855	Volcaniclastic Sediments—sand to gravel size dacitic, rhyolitic, and pumiceous sediments. 815–855 ft WR: 80–100% white ash from poorly welded ash flow tuff; <20% rounded, tan pumice clasts; trace lithic fragments +10F: 99–100% tan, rounded pumice clasts; trace lithic fragments. No returns to low sieve fraction volume. +35F: 90–100% white to tan pumice clasts; <10% volcanic lithic fragments	Tpf	**Note:** Samples in this section are largely composed of rounded pumices similar to Qbog samples and are interpreted to be from above. Cuttings returns while drilling 18-in. casing advance were poor.
855–860	No sample returns.	Tpf	
860–870	Volcaniclastic Sediments—varicolored grains of dacite and rhyolite. 860–870 ft WR/ +10F: 100% subangular grains of dacite and rhyolite up to 25 mm. +35F: 98–100% dacite and rhyolite grains; <2% quartz and sanidine grains.	Tpf	**Note:** Cutting returns while drilling 16-in. casing advance were poor. Often cuttings were obtained only at the end of each ~20 ft casing joint and therefore each interval with samples probably is representative of the above intervals with no sample returns.
870–900	No sample returns.	Tpf	

DEPTH (ft bgs)	LITHOLOGY	LITHOLOGIC SYMBOL	NOTES
900–905	Volcaniclastic Sediments—varicolored grains of dacite and rhyolite. 900–905 ft WR/ +10F: 100% subangular grains of dacite and rhyolite up to 8 mm. +35F: 99–100% dacite and rhyolite grains; trace devitrified pumice grains; trace quartz crystals.	Tpf	
905–915	No sample returns.	Tpf	
915–925	Volcaniclastic Sediments—varicolored grains of dacite and rhyolite. 915–925 ft WR/ +10F: 100% subangular to subrounded grains of dacite, rhyolite, and rhyolitic tuff up to 20 mm. +35F: 99–100% dacite and rhyolite grains; trace devitrified pumice grains; trace quartz crystals.	Tpf	
925–940	No sample returns.	Tpf	
940–945	Volcaniclastic Sediments—varicolored grains of dacite and rhyolite. 940–945 ft WR/ +10F: 100% subangular grains of dacite, rhyolite, and rhyolitic tuff up to 15 mm. +35F: 99–100% dacite and rhyolite grains; trace devitrified pumice grains; trace quartz crystals.	Tpf	
945–960	No sample returns.	Tpf	
960–985	Volcaniclastic Sediments—varicolored grains of dacite and rhyolite. 960–985 ft WR/ +10F: 100% angular to subangular grains of dacite, rhyolite, and rhyolitic tuff up to 10 mm. +35F: 99–100% dacite and rhyolite grains; trace devitrified pumice grains; trace quartz crystals.	Tpf	
985–1025	No sample returns.	Tpf	
1025–1035	Volcaniclastic Sediments—varicolored grains of dacite and rhyolite. 1025–1035 ft WR/ +10F: 100% subangular to rounded grains of dacite, rhyolite, and rhyolitic tuff up to 15 mm. +35F: Low sieve fraction volume	Tpf	
1035–1065	Volcaniclastic Sediments—varicolored grains of dacite and rhyolite. 1035–1065 ft WR/ +10F: 100% angular to subangular grains of dacite, rhyolite, and rhyolitic tuff up to 20 mm. +35F: 99–100% dacite and rhyolite grains; trace quartz crystals.	Tpf	

DEPTH (ft bgs)	LITHOLOGY	LITHOLOGIC SYMBOL	NOTES
1065–1080	Volcaniclastic Sediments—varicolored grains of dacite and rhyolite. 1065–1065 ft WR/ +10F: 100% angular to subangular grains of dacite, rhyolite, and rhyolitic tuff up to 5 mm. +35F: 99–100% dacite and rhyolite grains; trace quartz crystals.	Tpf	
1080–1105	Volcaniclastic Sediments—varicolored grains of dacite and rhyolite. 1080–1105 ft WR/ +10F: 100% angular to subangular grains of dacite, rhyolite, and rhyolitic tuff up to 20 mm. +35F: 99–100% dacite and rhyolite grains; trace quartz crystals.	Tpf	
1105–1185	Volcaniclastic Sediments—varicolored grains of dacite and rhyolite. 1105–1185 ft WR/ +10F: 100% angular to subangular grains of dacite, rhyolite, and rhyolitic tuff up to 15 mm. +35F: 99–100% dacite and rhyolite grains; trace quartz crystals.	Tpf	
1185–1245	Volcaniclastic Sediments—varicolored grains of dacite and rhyolite. 1185–1245 ft WR/ +10F: 100% angular to subangular grains of dacite, rhyolite, and rhyolitic tuff up to 25 mm. +35F: 99–100% dacite and rhyolite grains; trace quartz crystals.	Tpf	

ABBREVIATIONS

5YR 8/4 = Munsell rock color notation where hue (e.g., 5YR), value (e.g., 8), and chroma (e.g., 4) are expressed. Hue indicates soil color's relation to red, yellow, green, blue, and purple. Value indicates soil color's lightness. Chroma indicates soil color's strength.

% = Estimated percent by volume of a given sample constituent

amsl = Above mean sea level

bgs = Below ground surface

Qbt 4 = Unit 4 of the Tshirege Member of the Bandelier Tuff

Qbt 3 = Unit 3 of the Tshirege Member of the Bandelier Tuff

Qbt 2 = Unit 2 of the Tshirege Member of the Bandelier Tuff

Qbt 1v = Unit 1v (vapor-phase) of the Tshirege Member of the Bandelier Tuff

Qbt 1g = Unit 1g (glassy) of the Tshirege Member of the Bandelier Tuff

Qct = Cerro Toledo interval

Qbo = Otowi Member of Bandelier Tuff

Qbog = Guaje Pumice Bed

Tpf = Puye Formation

+10F = Plus No. 10 sieve sample fraction

+35F = Plus No. 35 sieve sample fraction

WR = Whole rock (unsieved sample)

1 mm = 0.039 in.

1 in. = 25.4 mm

Appendix B

Screening Groundwater Analytical Results for Well R-63i

B-1.0 SCREENING GROUNDWATER ANALYSES AT R-63i

R-63i is an intermediate aquifer monitoring well with one well screen from 1122.5 to1189.0 ft below ground surface (bgs) in Puye Formation volcaniclastic sediments. This appendix presents screening analytical results for samples collected during drilling and well development at R-63i.

Laboratory Analyses

Eight groundwater screening samples were collected during drilling and two groundwater screening samples were collected after well development. Los Alamos National Laboratory's (LANL's or the Laboratory's) Earth and Environmental Sciences Group 14 (EES-14) analyzed the drilling samples for RDX (hexahydro-1,3,5-trinitro-1,3,5-triazine) and the post-well development samples for anions, metals, RDX, and total organic carbon (TOC). Table B-1.0-1 lists the samples submitted for analysis from R-63i. Table B-1.0-2 (included on CD) contains the screening results.

Field Analyses

Additionally, groundwater samples collected after well development were measured for pH, conductivity, temperature, dissolved oxygen (DO), oxidation-reduction potential (ORP) and turbidity.

B-2.0 SCREENING ANALYTICAL RESULTS

This section presents the TOC concentrations and field parameters measured after well development.

B-2.1 Total Organic Carbon

TOC concentrations were 1.14 mgC/L and 1.84 mgC/L in two groundwater samples collected after well development at well R-63i (Table B-2.1-1). These concentrations are below the target concentration of 2.0 mgC/L for TOC at the end of well development. Table B-2.1-1 also presents the U.S. Environmental Protection Agency (EPA) method by which the samples were analyzed.

B-2.2 RDX

RDX concentrations ranged from 0.0114 mg/L to 0.0460 mg/L in three groundwater samples collected during drilling at well R-63i (Table B-2.2-1). The highest concentration of 0.046 mg/L was from a sample collected at 864 ft bgs. Two samples collected between 1175 ft and 1185 ft bgs had concentrations of 0.011 mg/L. All other samples were below the detection limits. RDX concentrations for two groundwater samples collected after well development were below the detection limits (Figure B-2.2-1).

B-2.3 Field Parameters

Field parameters measured during and after well development are summarized in Table B-2.3-1. Well development was initially conducted for 7 d. Development was then conducted for an additional 6 d. The field parameters are summarized below.

During and after well development, pH varied from 6.0 to 9.19 and temperature ranged from 9.40°C to 14.50°C. DO concentrations varied from 4.58 mg/L to 10.55 mg/L. Specific conductance ranged from 90 μS/cm to 270 μS/cm, and turbidity values varied from 154.6 to 1479.0 nephelometric turbidity units

(NTU). Corrected Eh values, determined from field ORP measurements, varied from 193.2 to 420.6 mV. One temperature-dependent correction factor was used to calculate Eh values from field ORP measurements: 208.9 mV at 15ºC. Figure B-2.3-1 shows the field parameters measured over the course of well development and post-well development.

The final parameters measured at the end of post-well development were pH of 6.0, temperature of 11.84ºC, DO of 6.30 mg/L, specific conductance of 262 μS/cm, and turbidity of 154.6 NTU.

B-3.0 SUMMARY OF SCREENING ANALYTICAL RESULTS

TOC concentrations were below the target level of 2.0 mgC/L and turbidity was 154.6 NTU after well development. The RDX concentrations ranged from 0.0114 mg/L to 0.0460 mg/L during drilling. Samples collected after initial development were below the detection limit for RDX.

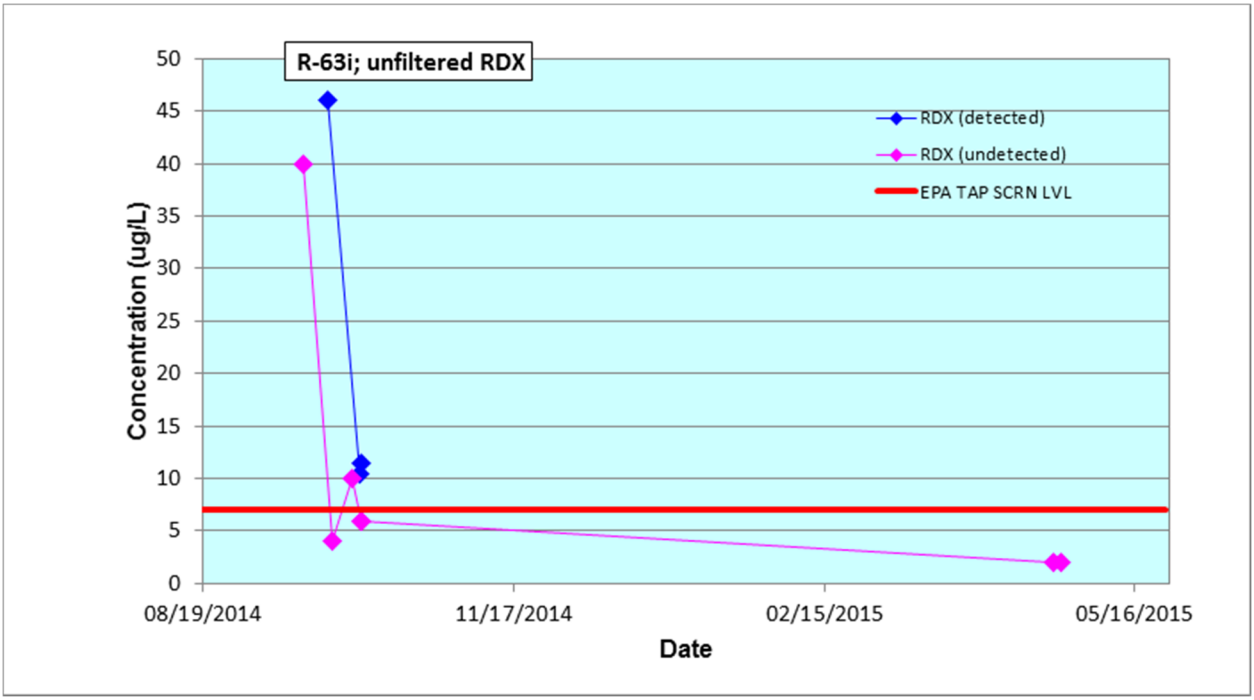


Figure B-2.2-1 RDX sample measurements during R-63i drilling and well development

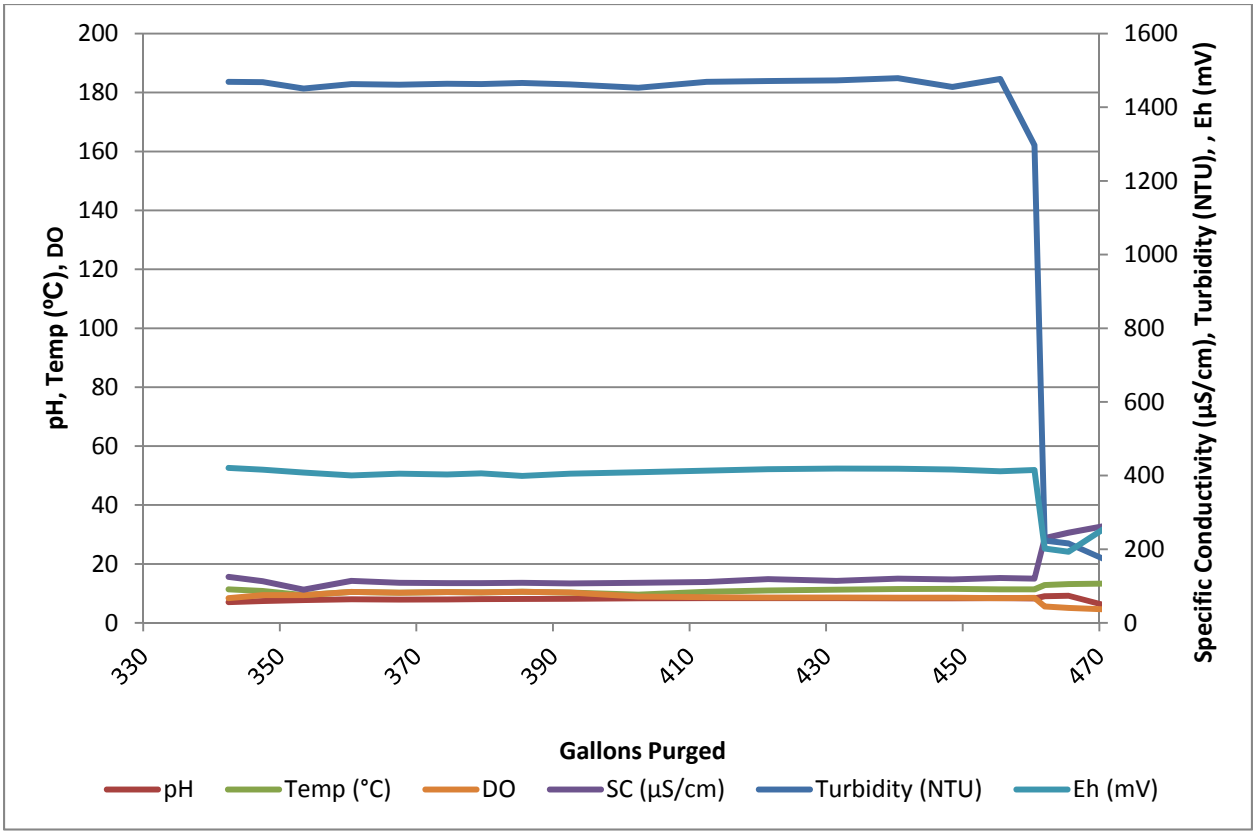


Figure B-2.3-1 Field parameters versus volume purged during R-63i well development

Table B-1.0-1
Summary of Groundwater Screening Samples Collected during Drilling and Well Development at Well R-63i

Location ID	Sample ID	Date Collected	Collection Depth (ft bgs)	Sample Type	Analysis
Drilling					
R-63i	CACV-14-85704	9/16/14; 2110h	775	Groundwater, Air lifted	RDX
R-63i	CACV-14-85705	9/23/14; 2258h	864	Groundwater, Air lifted	RDX
R-63i	CACV-14-85706	9/25/14; 0510h	1025	Groundwater, Air lifted	RDX
R-63i	CACV-14-85707	10/1/14; 0545h	1175	Groundwater, Air lifted	RDX
R-63i	CACV-14-85708	10/3/14; 1215h	1175	Groundwater, Air lifted	RDX
R-63i	CACV-14-85709	10/3/14; 1410h	1185	Groundwater, Air lifted	RDX
R-63i	CACV-14-85710	10/3/14; 1545h	1205	Groundwater, Air lifted	RDX
R-63i	CACV-14-85711	10/3/14; 1737h	1225	Groundwater, Air lifted	RDX
Well Development					
R-63i	CACV-15-95835	4/22/15; 1305h	1185	Groundwater, Bailed	RDX, TOC, anions, metals
R-63i	CACV-15-95836	4/24/15; 1215h	1186	Groundwater, Bailed	RDX, TOC, anions, metals

Table B-2.1-1
TOC Results

Location ID	EPA Method	TOC Concentration (mgC/L)
CACV-15-95835	SW-846:9060	1.14
CACV-15-95836	SW-846:9060	1.84

Table B-2.2-1
RDX Results

Location ID	RDX (mg/L)	Detection Limit
CACV-14-85704	BDL*	0.04
CACV-14-85705	0.0460	0.002
CACV-14-85706	BDL	0.004
CACV-14-85707	BDL	0.01
CACV-14-85708	0.0105	0.002
CACV-14-85709	0.0114	0.002
CACV-14-85710	BDL	0.006
CACV-14-85711	BDL	0.006
CACV-15-95835	BDL	0.002
CACV-15-95836	BDL	0.002

* BDL = below detection limit.

Table B-2.3-1
Purge Volumes and Field Parameters during Well Development at R-63i

Date	pH	Temp (°C)	DO (mg/L)	ORP (mV)	Eh (mV)	Specific Conductance (µS/cm)	Turbidity (NTU)	Purge Volume between Samples (gal.)	Cumulative Purge Volume (gal.)
Well Development									
11/11 to 11/17/14	n/r*; bailing							206.5	206.5
12/5 to 12/8/14	n/r; bailing							130	336.5
1/23/15	7.03	11.40	8.39	211.7	420.6	125	1469	6	342.5
	7.43	10.84	9.40	206.9	415.8	113	1468	5	347.5
	7.74	9.40	9.40	199.4	408.3	90	1451	6	353.5
	7.99	10.52	10.52	191.6	400.5	114	1463	7	360.5
	7.92	10.22	10.22	196.4	405.3	109	1461	7	367.5
	7.97	10.46	10.46	193.9	402.8	108	1464	7	374.5
	8.07	10.33	10.33	197.1	406.0	108	1463	5	379.5
	8.13	10.55	10.55	190.0	398.9	109	1466	6	385.5
	8.17	10.27	10.27	196.1	405.0	107	1462	7	392.5
1/24/15	8.32	9.57	8.93	200.3	409.2	109	1453	10	402.5
	8.39	10.57	8.71	204.5	413.4	111	1469	10	412.5
	8.37	11.02	8.63	208.2	417.1	119	1471	9	421.5
	8.39	11.25	8.60	210.1	419.0	114	1473	10	431.5
	8.36	11.50	8.55	209.8	418.7	120	1479	9	440.5
	8.36	11.55	8.54	207.3	416.2	118	1455	8	448.5
	8.41	11.37	8.38	202.9	411.8	122	1477	7	455.5
	8.30	11.38	8.52	206.2	415.1	120	1297	5	460.5
Post-Well Development									
4/20/15	9.04	12.84	5.55	-7.3	201.6	230	223.6	1.5	462
	9.19	13.17	5.07	-15.7	193.2	245	215.9	3.5	465.5
4/22/15	6.0	13.34	4.58	48.0	256.9	263	172.4	5.3	470.8
	6.0	12.52	5.32	10.6	219.5	262	174.4	3.3	474.1
	7.0	14.50	5.60	-1.7	207.2	270	195.1	4	478.1
4/24/15	6.0	11.84	6.30	40.5	249.4	262	154.6	3.6	481.7

Note: One temperature-dependent correction factor was used to calculate oxidation-reduction potential (Eh) values from field ORP measurements: 208.9 mV at 15ºC.

* n/r = Not recorded.

Appendix C

Geophysical Logs
(on CD included with this document)

Appendix D

Borehole Video Logging
(on DVDs included with this document)

Appendix E

Final Well Design and
New Mexico Environment Department Approval

Proposed R-63i Well Design and Justification

R-63i Well Objectives

Well R-63i is being installed to satisfy a requirement made in the Approval with Modifications Technical Area 16 Well Network Evaluation and Recommendations from the New Mexico Environment Department (NMED) Hazardous Waste Bureau (LANL 2012, 213573; NMED 2012, 520747). This letter required the installation of a deep perched-intermediate groundwater monitoring well east of Material Disposal Area (MDA) P. The well was sited next to existing regional aquifer well R-63 (Figure 1). The primary purpose of R-63i is to monitor contaminant releases from the 260 Outfall and MDA P as well as recharge from Cañon de Valle. Water-level data from this location will also constrain the shape of the lower deep-intermediate aquifer and groundwater flow directions in this area. The target depth for the R-63i borehole was 1200 ft, about 60 ft above the regional aquifer. The well was planned with the understanding that the depth and occurrence of deep perched groundwater was uncertain, and the target depth would be adjusted as new borehole information became available to better plan the installation of an intermediate well.

R-63i Recommended Well Design

It is recommended that R-63i be installed as a single-screen well with a 60-ft stainless-steel, 40 slot, wire-wrapped well screen extending from 1129 ft to 1189 ft bgs. The primary filter pack will consist of 10/20 sand extending 8 ft above and 5 ft below the screen openings. A 2-ft secondary filter pack will be placed above the primary filter pack. The proposed well design is shown in Figure 2.

This well design is based on the objectives stated above and on the information summarized below.

R-63i Well Design Considerations

The R-63i borehole was drilled to a total depth of 1245 ft. Preliminary lithological logs indicate that the geologic contacts are, in descending stratigraphic order: ash-flow tuffs of the Tshirege and Otowi Members of the Bandelier Tuff with intercalated sedimentary deposits of the Cerro Toledo interval (0–796 ft) and boulders, cobbles, gravels, sands, and silts of the Puye Formation (796–1245 ft TD). The Puye Formation is the primary target for the well screen. Borehole video logs at R-63i and nearby well R-63 indicate that the Puye Formation is a coarse fanglomerate made up of boulder and cobble deposits that are stacked in beds 1 to 5 ft thick. Boulders and cobbles occur in matrix- and clast-supported beds separated by sandy gravels and relatively rare thin silt beds.

Characterization activities included the collection of cuttings at 5 ft intervals, a LANL gamma log from 0 to 1220 ft, induction logs from 1104 to 1220 ft and 1158 to 1240 ft, open borehole video logs from 1104 to 1182 ft and 1165 to 1199 ft, and water-level measurements.

A possible upper-perched groundwater zone was encountered in the lower Otowi Member and top of the Puye Formation with a depth-to-water of about 750 ft bgs. This upper-perched groundwater was sealed out of the borehole by landing 18-in drill casing in bentonite at 852 ft bgs. The borehole was advanced to a depth of 1027.7 ft where 16-in casing was landed in bentonite to prevent potential perched water in the 852- to 1027.7-ft interval from following the advancing borehole. The 12.75-in drill casing was advanced to 1175 ft depth where drilling was halted to determine if perched water was present. The 12.75-in casing was pulled back to 1173 ft and the hole filled with water to a stable water level of 1123 ft bgs. The borehole was then advanced to 1225 ft, casing was pulled back to 1224 ft, and a water level of 1208 ft was measured. Then, the 12.75-in casing was retracted to 1104 ft to visually evaluate where water was entering the borehole using the borehole camera and to collect gamma and induction logs. The borehole video showed no significant

production of groundwater from the borehole walls below the casing and a stable water level occurred at 1182.5 ft depth. The borehole was then advanced to 1245 ft to look for deeper productive zones and to better evaluate potential confining beds for perched groundwater. No water was produced at 1245 ft with the casing retracted one foot, so the casing was retracted to 1225 ft where a static water level of 1217 ft was observed. Then, the 12.75-in casing was retracted to 1165 ft so the bottom section of the borehole could be logged by borehole camera and the induction tool. The borehole video showed water dripping at a moderate rate from the bottom of the 12.75-in casing at 1165 ft depth. This water trickled down the borehole wall to standing water at 1199 ft; stronger sheet flow on the borehole wall occurred below 1190 ft. The water level eventually stabilized at 1186.5 ft depth, recharging the borehole at an approximate rate of 0.4 gal/min.

The observations described above are supplemented by observations made when the borehole for well R-63 was drilled in 2010 and 2011. A borehole video made 1/27/2011 shows little to no groundwater flow on the R-63 borehole wall from 1164 ft (bottom of casing) to 1178 ft depth. Below 1178 ft, there is strong sheet flow of water on the borehole wall down to standing water at 1258 ft depth. Although the top of saturation is well-defined, the perching horizon could not be determined.

Based on video logs, flow of water on the borehole wall occurred at 1190 ft depth at R-63i and 1178 ft depth at R-63. Additionally, a stable water level of 1182 occurred at R-63i in uncased borehole when the TD was 1225 ft and a stable water level of 1186 ft occurred in uncased borehole when the TD was 1245 ft. Based on these observations it is expected that the water level in the proposed well will be between 1182 and 1186 ft depth, or 3 to 7 ft above the bottom of the well screen. There is the possibility that a small amount of water is seeping into the borehole at 1123 ft where a stable water level was established when the cased borehole TD was 1175 ft, however this zone is not apparent on the open hole video for this zone. However, if present and contributing to the well, the water level in the proposed well may be higher than 3 to 7 ft above the bottom of the well screen. Potential confining beds for the observed perched water were identified as silt beds or gravel and cobble beds with a silt-rich matrix at depths of 1190 to 1206 ft and 1209 to 1215 ft from borehole videos and induction logs. Because it is not possible to determine which of the silt-rich beds form the confining bed, the well design assumes the uppermost silt-rich beds in the 1190 to 1205 ft interval form the primary confining zone. The 60-ft-long screen was chosen because there are substantial uncertainties about the depths where stringers of groundwater are entering the borehole. Additionally, the filter pack above the well screen is 8 ft in length to allow potential saturation associated with the 1123-ft water level observation to enter the well.

Installation of a well at this location includes significant risks. The low productivity and thin nature of the perched zone will severely constrain development of the completed well. Additionally, because the water flow to the well is fed by thin stringers of saturated gravels, these may dewater over time causing water levels to decline even further. The sampling protocol for the well may need to be modified because purging three casing volumes in such a potentially-low yield zone may not be feasible.

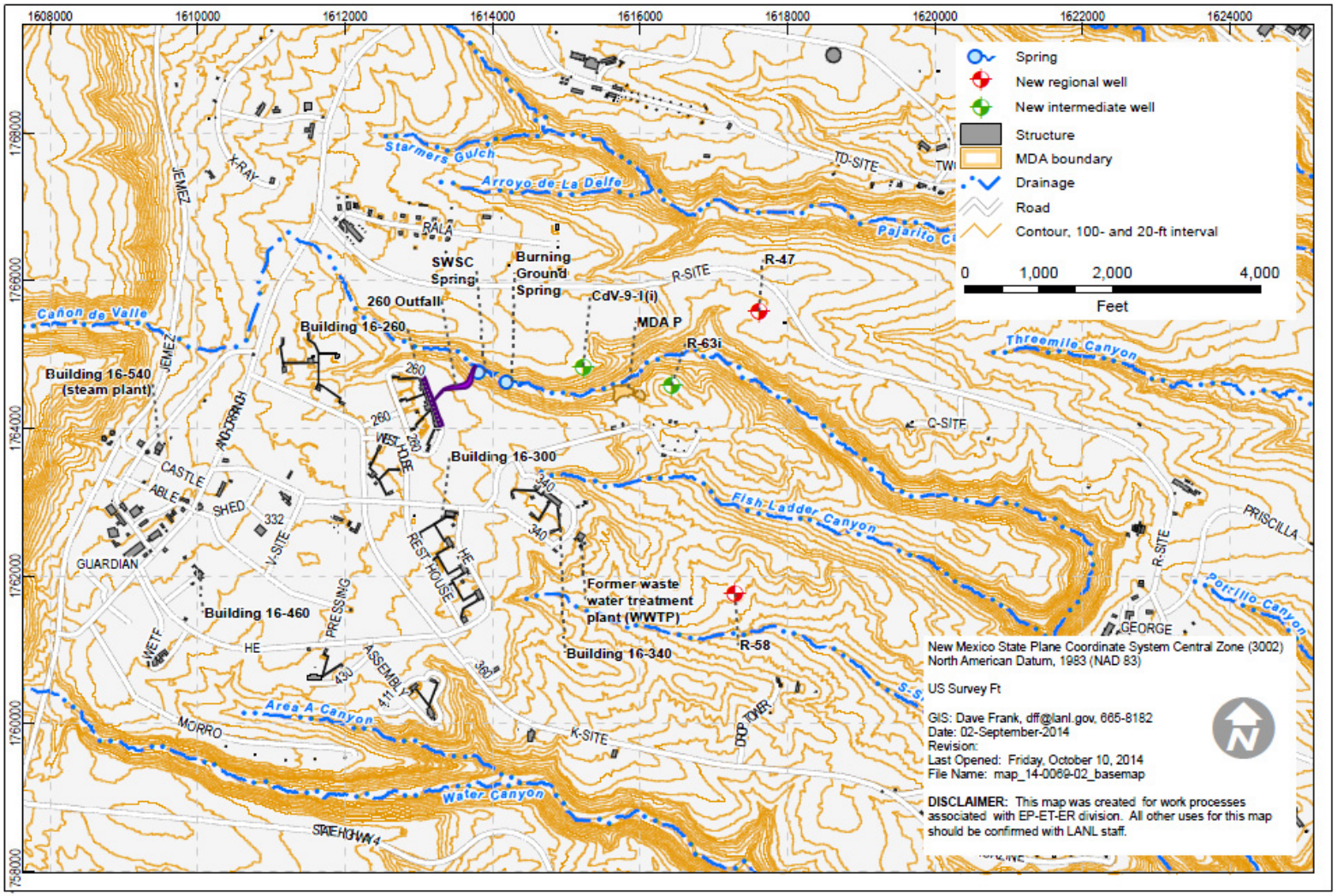


Figure 1 **Map of well R-63i location**

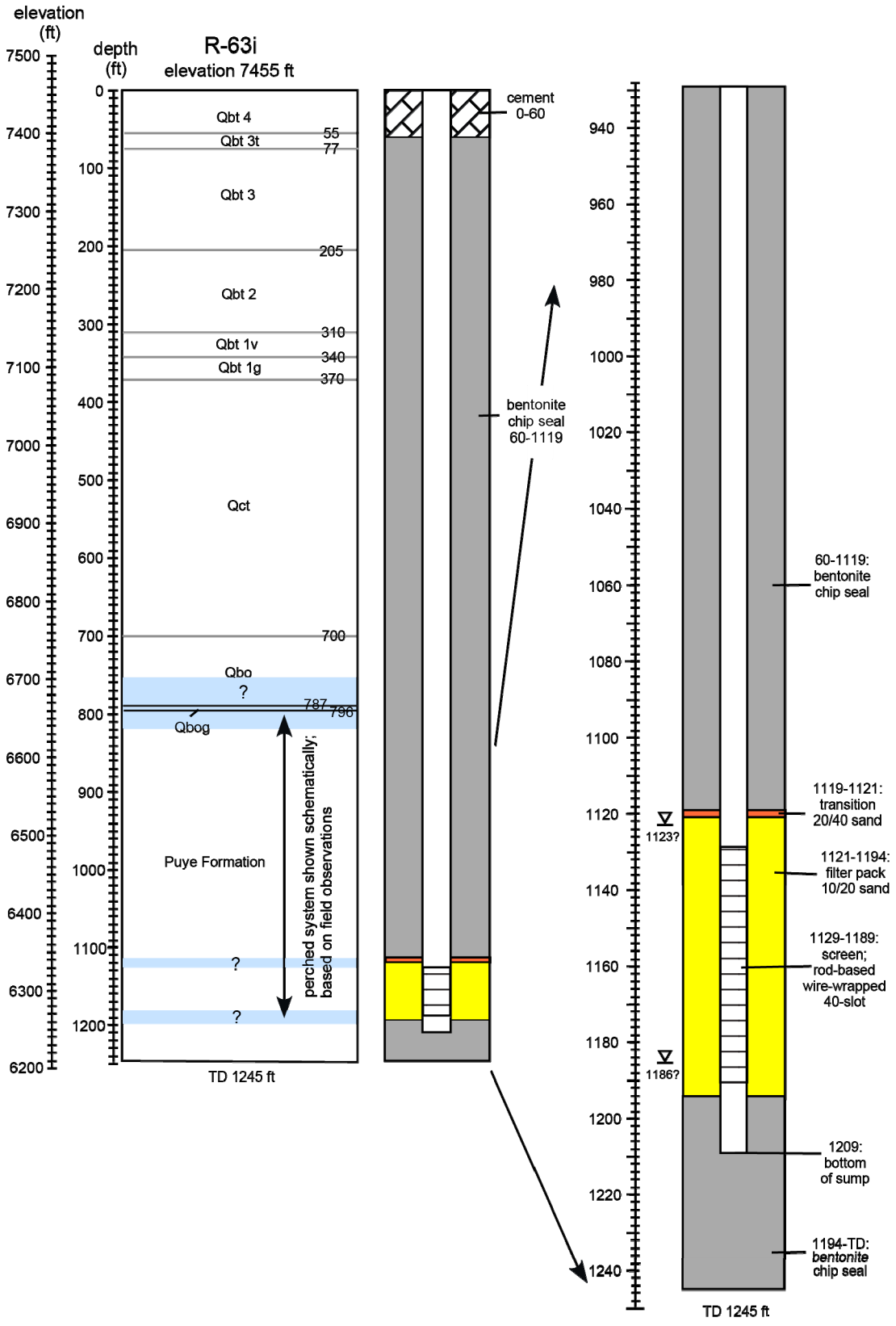


Figure 2 Proposed well design for R-63i

From: Kulis, Jerzy, NMENV [mailto:jerzy.kulis@state.nm.us]
Sent: Friday, October 10, 2014 5:17 PM
To: Goering, Tim J
Cc: Paris, Steven M; Thacker, Mark Sloan; Shen, Hai; Dale, Michael, NMENV; Cobrain, Dave, NMENV; Wear, Benjamin, NMENV
Subject: RE: PDF Version of R-63i Well Design file

Tim,

NMED hereby approves the installation of well R-63i as proposed in your e-mail below. This approval is based on information available to NMED at the time of the approval. LANL must provide the results of groundwater sampling, any modifications to the well design proposed in the above-mentioned e-mail, and any additional information relevant to the installation of R-63i as soon as such data or information becomes available.

Please let me know if you have any questions.

Jerzy Kulis
Environmental Scientist
Hazardous Waste Bureau
New Mexico Environment Department
2905 Rodeo Park Drive East, Bldg 1
Santa Fe, NM 87505-6303
Phone: 505-476-6039
Fax: 505-476-6030

From: Goering, Tim J [goering@lanl.gov]
Sent: Friday, October 10, 2014 4:20 PM
To: Kulis, Jerzy, NMENV
Cc: Paris, Steven M; Thacker, Mark Sloan; Shen, Hai; Dale, Michael, NMENV; Cobrain, Dave, NMENV
Subject: PDF Version of R-63i Well Design file

Jerzy,

Attached is the PDF version of the R-63i Well Design file (that I previously sent over in MS Word format) for your review and approval.
I had intended to send over the PDF version for your review.

Thank you.

Tim Goering
CAP ES

From: Goering, Tim J
Sent: Friday, October 10, 2014 4:14 PM
To: Kulis, Jerzy, NMENV
Cc: Broxton, David E; Paris, Steven M; Katzman, Danny; Steve Pearson (spearson@lanl.gov); Cobrain, Dave, NMENV; Dale, Michael, NMENV; Thacker, Mark Sloan
Subject: Proposed R-63i Well Design for NMED Review and Approval

Jerzy,

Attached for your review and approval is the proposed R-63i well design and justification. We will await your response. Thank you.

Tim Goering
LANL CAP-ES
Tel 5-0996