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Los Alamos
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Associate Director for ESH
Environment, Safety, and Health
P.O. Box 1663, MS K491
Los Alamos, New Mexico 87545
505-667-4218/Fax 505-665-3811

National Nuclear Security Administration
Los Alamos Field Office, MS A316
Environmental Projects Office
Los Alamos, New Mexico 87544
(505) 667-4255/FAX (505) 606-2132

Date: NOV 25 2014
Refer To: ADESH-14-125

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 Regional Aquifer Well R-47

Dear Mr. Kieling:

Enclosed please find two hard copies with electronic files of the Completion Report for Regional Aquifer Well R-47.

If you have any questions, please contact John McCann at (505) 665-1091 (jmccann@lanl.gov) or Hai Shen at (505) 665-5046 (hai.shen@nnsa.doe.gov).

Sincerely,

Michael T. Brandt, DrPH, CIH, Associate Director
Environment, Safety, and Health
Los Alamos National Laboratory

Sincerely,

Peter Maggiore, Assistant Manager
Environmental Projects Office
Los Alamos Field Office

36752

MB/PM/DM/JM:sm

Enclosures: Two hard copies with electronic files – Completion Report for Regional Aquifer Well R-47 (LA-UR-14-28638)

Cy: (w/enc.)
John McCann, EP-CAP, MS M992
Public Reading Room (EPRR)
ADESH records (electronic copy)

Cy: (Letter and CD and/or DVD)
Laurie King, EPA Region 6, Dallas, TX
Steve Yanicak, NMED-DOE-OB, MS M894
Steve White, TPMC (w/ MS Word files on CD)
PRS Database

Cy: (w/o enc.)
Tom Skibitski, NMED-DOE-OB (date-stamped letter emailed)
lasomailbox@nnsa.doe.gov
Annette Russell, DOE-NA-LA (date-stamped letter emailed)
David Rhodes, DOE-NA-LA (date-stamped letter emailed)
Kimberly Davis Lebak, DOE-NA-LA (date-stamped letter emailed)
Hai Shen, DOE-NA-LA (date-stamped letter emailed)
Dave McInroy, EP-CAP (date-stamped letter emailed)
Randy Erickson, ADEP (date-stamped letter emailed)
Tony Grieggs, ADESH-ENV-CP (date-stamped letter emailed)
Alison Dorries, ADESH-ENV-DO (date-stamped letter emailed)
Michael Brandt, ADESH (date-stamped letter emailed)

LA-UR-14-28638
November 2014
EP2014-0517

Completion Report for Regional Aquifer Well R-47

Los Alamos
NATIONAL LABORATORY
EST. 1943

Prepared by the Environmental Programs Directorate

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EP2014-0517

Completion Report for Regional Aquifer Well R-47

November 2014

Responsible project manager:

Printed Name	Signature	Title	Organization	Date
John McCann		Project Manager	Environmental Programs	11-19-2014

Responsible LANS representative:

Printed Name	Signature	Title	Organization	Date
Randall Erickson		Acting Associate Director	Environmental Programs	11/19/14

Responsible DOE representative:

Printed Name	Signature	Title	Organization	Date
Peter Maggiore		Assistant Manager	DOE-NA-LA	11/24/14

EXECUTIVE SUMMARY

This well completion report describes the drilling, well construction, development, aquifer testing, and dedicated sampling system installation for regional aquifer groundwater well R-47, located within Los Alamos National Laboratory (LANL or the Laboratory) at Technical Area 14 (TA-14) in Los Alamos County, New Mexico. The R-47 monitoring well is intended to augment the existing monitoring well network to better define RDX (hexahydro-1,3,5-trinitro-1,3,5-triazine) contamination flow paths within the regional aquifer north of Cañon de Valle. The primary purpose of R-47 is to provide groundwater monitoring for high explosives and other potential contaminants in the regional aquifer downgradient of the 260 Outfall at TA-16 and beneath infiltration pathways associated with Cañon de Valle, as required by the New Mexico Environment Department's (NMED's) approval with modifications for drilling work plan for regional aquifer well R-47.

The R-47 monitoring well 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 1145 ft below ground surface (bgs), approximately 105 ft above the top of the regional aquifer.

The following geologic formations were encountered at R-47: Tshirege Member of the Bandelier Tuff, Cerro Toledo interval, Otowi Member of the Bandelier Tuff, Guaje Pumice Bed of the Otowi Member, and the Puye Formation. Well R-47 was drilled to a total depth of 1397 ft bgs.

Well R-47 was completed as a single-screen well to allow for evaluation of water quality and water levels within the regional aquifer. The screened interval is set between 1322.0 ft and 1343.3 ft bgs within Puye Formation sediments. The static depth to water after well installation was measured at 1303.3 ft bgs.

The well was completed in accordance with an NMED-approved well design. The well was developed and the regional aquifer groundwater met target water-quality parameters. Aquifer testing indicates regional aquifer monitoring well R-47 is productive and will perform effectively to meet the planned objectives. A sampling system and transducer have been placed in the screened interval, and groundwater at R-47 will be sampled 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
bgs	below ground surface
Consent Order	Compliance Order on Consent
DO	dissolved oxygen
DTW	depth to water
Eh	oxidation-reduction potential
ESH-OIO	Environment, Health, and Safety–Operations Integration Office
gpd	gallons per day
gpm	gallons per minute
hp	horsepower
I.D.	inside diameter
LANL	Los Alamos National Laboratory
NAD	North American Datum
NMED	New Mexico Environment Department
NTU	nephelometric turbidity unit
O.D.	outside diameter
ORP	oxidation-reduction potential

PLY	Pajarito Laydown Yard
PVC	polyvinyl chloride
RDX	hexahydro-1,3,5-trinitro-1,3,5-triazine
SOP	standard operating procedure
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, well development, aquifer testing, and dedicated sampling system installation for regional aquifer monitoring well R-47. The report is written in accordance with the requirements in Section IV.A.3.e.iv of the March 1, 2005 (revised 2008), Compliance Order on Consent (the Consent Order). The R-47 monitoring well borehole was drilled between July 26 and September 11, 2014, and completed between September 14 and September 29, 2014, at Los Alamos National Laboratory (LANL or the Laboratory) for the Environmental Programs Directorate.

Well R-47 is located within the Laboratory's Technical Area 14 (TA-14) in Los Alamos County, New Mexico (Figure 1.0-1). Well R-47 was installed to provide groundwater monitoring for high explosives and other potential contaminants in the regional aquifer downgradient of the 260 Outfall at TA-16 and beneath infiltration pathways associated with Cañon de Valle. Secondary objectives were to establish water levels in the regional aquifer and identify potential perched aquifers and to collect samples of drill cuttings.

The R-47 borehole was drilled to a total depth (TD) of 1397 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 1322.0 ft and 1343.3 ft bgs within Puye Formation volcaniclastic sediments. The depth to water (DTW) of 1303.3 ft bgs was recorded on October 3, 2014, after well installation.

Post-installation activities included developing the well, conducting aquifer testing, performing surface completion, conducting a geodetic survey, and installing a sampling system. 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 Laboratory's Records Processing Facility. This report contains brief descriptions of activities and supporting figures, tables, and appendixes associated with the R-47 project.

2.0 ADMINISTRATIVE PLANNING

The following documents guided activities associated with the drilling, installation, and development of regional aquifer well R-47:

- "Drilling Work Plan for Regional Aquifer Well R-47" (LANL 2012, 232340);
- "Approval with Modifications, Drilling Work Plan for Regional Aquifer Well R-47" (NMED 2012, 521583);
- "Field Implementation Plan for Regional Aquifer Well R-47" (TerranearPMC 2014, 262888);
- "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 Wells Drilling" (LANL 2006, 092600); and
- "Waste Characterization Strategy Form for 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-47.

3.1 Drilling Approach

The drilling methodology, equipment, and drill-casing sizes for the R-47 monitoring well were selected to retain the ability to investigate and case/seal off any perched groundwater encountered above the regional aquifer. Furthermore, the drilling approach ensured that a sufficiently sized drill casing was used to meet the required 2-in.-diameter minimum annular thickness of the filter pack around a 5.88-in. outside-diameter (O.D.) well screen.

Both conventional air-rotary, using an LM140 drill rig, and dual-rotary, using a Foremost DR-24HD drill rig, drilling methods were employed to drill the R-47 borehole. The LM140 drill rig was used to accelerate the project schedule until the DR-24HD drill rig became available. The drill rigs were equipped with conventional drilling rods, tricone bits, downhole hammer bits, deck-mounted air compressors, and general drilling equipment. Auxiliary equipment included two Ingersoll Rand skid-mounted air compressors and one Ingersol Rand truck-mounted compressor. Three sizes of A53 grade B flush-welded mild carbon-steel casing (24-in. and 16-in. O.D., and 12-in. inside-diameter [I.D.]) were used for the R-47 project.

Rotary and dual-rotary drilling techniques at R-47 used filtered compressed air and fluid-assisted air to evacuate cuttings from the borehole during drilling. Drilling fluids, other than air, included potable water and a mixture of potable water with Baroid Quik Foam foaming agent. The fluids were used to cool the bit and help lift cuttings from the borehole. In accordance with the approved drilling work plan, use of the foaming agent was terminated at 1145 ft bgs, roughly 105 ft above the expected top of the regional aquifer (LANL 2012, 232340; NMED 2012, 521583). No additives other than potable water were used for drilling below 1145 ft bgs. Total amounts of drilling fluids introduced into the borehole are presented in Table 3.1-1.

3.2 Chronological Drilling Activities for the R-47 Well

The LM140 drill rig, drilling equipment, and supplies were mobilized to the R-47 drill site from July 23 to July 25, 2014. The equipment and tooling were decontaminated before mobilization to the site. On July 26, following on-site equipment inspections, the monitoring well borehole was initiated at 1225 h using open-hole rotary methods with a 28-in.-diamter tricone bit.

A 28-in.-diameter open hole was drilled to 58 ft bgs in unit 3 of the Tshirege Member of the Bandelier Tuff, and a 24-in.-diameter surface casing was then installed to 60 ft bgs. Hydrated bentonite and drill cuttings were used to fill and seal the annulus around the surface casing.

On July 27, open-hole drilling commenced using a 22-in.-diameter tricone bit. Drilling proceeded through the Tshirege Member, the Cerro Toledo interval, the Otowi Member, the Guaje Pumice Bed of the Otowi Member, and the top of the Puye Formation to 847 ft bgs on July 30 (the night shift).

The LM140 drill rig was removed from the R-47 drill site and on August 2, the Foremost DR-24HD dual-rotary rig was mobilized to the site. From August 7 to August 10 and from August 18 to August 19, a 16-in.-diameter casing string was installed in the open borehole to a depth of 832 ft bgs. From August 22 to August 24, a 16-in.-diameter underreaming hammer bit was used to advance the 16-in.-diameter

casing through volcaniclastic sediments to 1145 ft bgs. The 16-in.-diameter casing shoe was cut on August 25 at 1137 ft bgs before the 12-in.-diameter casing string was installed.

Between August 25 and August 28, a 12-in.-diameter casing string was installed to a depth of 1145 ft bgs. The 12-in.-diameter casing string and an underreaming hammer bit were advanced through the Puye Formation to 1397 ft bgs. Water was encountered at approximately 1235 ft bgs on August 30. Casing-advance drilling proceeded to TD at 1397 ft bgs on September 3. After reaching TD, the underreaming hammer bit could not be pulled back through the 12-in.-diameter casing. Between September 3 and September 10, the 12-in.-diameter casing string and drill string were simultaneously removed from the borehole and the 12-in.-diameter casing string was reinstalled. The lower 2 ft of the 12-in.-diameter casing was determined to be deformed, which kept the underreaming hammer bit from fitting. The underreaming hammer bit was used again on September 10 to clean out slough in the borehole, and on September 11, the 12-in.-diameter casing advance again proceeded to TD at 1397 ft bgs. The 12-in.-diameter casing shoe was cut on September 12 at 1392 ft bgs.

During drilling, field crews worked 24-h shifts, 7 d/wk. With the exception of the deformed casing at the end of borehole drilling, 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-47. All sampling activities were conducted in accordance with applicable quality procedures.

4.1 Cuttings Sampling

Cuttings samples were collected from the R-47 monitoring well borehole at 5-ft intervals from ground surface to the TD of 1397 ft bgs. At each interval, the site geologist collected approximately 500 mL of bulk cuttings from the drilling discharge cyclone, placed it in resealable plastic bags, labeled it, and archived it in core boxes. Whole rock and +35 and +10 sieve-size fractions were also processed, placed in chip trays, and archived for each 5-ft interval. Radiological control technicians screened the cuttings before they were removed 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 of R-47 is summarized in section 5.1, and a detailed lithologic log is presented in Appendix A.

4.2 Water Sampling

Six groundwater-screening samples were collected during development from the pump's discharge line for total organic carbon (TOC) analysis. (Table 4.2-1). The TOC results are presented in Appendix B. Two samples were collected during aquifer testing and analyzed for RDX (hexahydro-1,3,5-trinitro-1,3,5-triazine), a high explosive compound.

Groundwater characterization samples will be collected from the completed well in accordance with the Consent Order. For the first year, the samples will be analyzed for the full suite of constituents, including high explosives; radionuclides; anions/cations; general inorganic chemicals; volatile and semivolatile organic compounds; and stable isotopes of hydrogen, nitrogen, and oxygen. The analytical results will be included in the appropriate periodic monitoring reports issued by the Laboratory. After the first year, the

analytical suite and sample frequency at R-47 will be evaluated and presented in the annual "Interim Facility-Wide Groundwater Monitoring Plan."

5.0 GEOLOGY AND HYDROGEOLOGY

A brief description of the geologic and hydrogeologic features encountered at R-47 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-47.

5.1 Stratigraphy

Rock units for the R-47 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-47. A detailed lithologic log for R-47 is presented in Appendix A.

Unit 4, Tshirege Member of the Bandelier Tuff, Qbt 4 (0–40 ft bgs)

Unit 4 of the Tshirege Member of the Bandelier Tuff was encountered from 0 to 40 ft bgs. Qbt 4 is a light brownish-gray, poorly welded tuff that includes abundant altered glass fragments within the matrix. Tuff fragments also contain sparsely distributed light purplish-gray devitrified pumice clasts.

Unit 3, Tshirege Member of the Bandelier Tuff, Qbt 3 (40–180 ft bgs)

Unit 3 of the Tshirege Member of the Bandelier Tuff was encountered from 40 ft to 180 ft bgs. Qbt 3 is a light to medium gray, devitrified ash-flow tuff. It is more strongly welded than Qbt 4 and contains abundant crystals and minor lithic clasts embedded in a devitrified matrix.

Unit 2, Tshirege Member of the Bandelier Tuff, Qbt 2 (180–280 ft bgs)

Unit 2 of the Tshirege Member of the Bandelier Tuff was intersected from 180 ft to 280 ft bgs. Qbt2 is a light greenish-gray ash-flow tuff with a moderately to strongly welded matrix containing abundant quartz and feldspars and minor lithic fragments.

Unit 1v, Tshirege Member of the Bandelier Tuff, Qbt 1v (280–325 ft bgs)

Unit 1v of the Tshirege Member of the Bandelier Tuff occurs from 280 ft to 325 ft bgs. Qbt1v is a light to medium gray, partially to nonwelded ash-flow tuff containing partially collapsed devitrified pumice clasts. The individual devitrified pumice clasts exhibit distinct linear corrugated features of shards. The tuff is crystal-rich, and quartz and feldspar grains are often embedded in a white, devitrified ash matrix.

Unit 1g, Tshirege Member of the Bandelier Tuff, Qbt 1g (325–365 ft bgs)

Unit 1g of the Tshirege Member of the Bandelier Tuff was encountered from 325 ft to 375 ft bgs. Qbt1g is a nonwelded, glassy ash-flow tuff containing light to medium pumice clasts mixed with abundant crystals and minor lithic fragments.

Cerro Toledo Interval, Qct (365–550 ft bgs)

The Cerro Toledo interval was encountered from 375 ft to 550 ft bgs. Qct contains abundant reworked pumice, crystals, and rhyolite lithic fragments, including few obsidian fragments. Pumice clasts are rounded and white and are mixed with abundant coarse lithic fragments. The reworked pumice clasts transition with depth to light brown, wood-chip like fragments.

Otowi Member of the Bandelier Tuff, Qbo (550–725 ft bgs)

The Otowi Member of the Bandelier Tuff was encountered from 550 ft to 725 ft bgs. Qbo is a lithic-rich ash-flow tuff, containing variable amounts of light to medium gray pumice clasts. Lithic fragments are slightly different (i.e., more dacitic) from those present in the Qct unit.

Guaje Pumice Bed of the Otowi Member of the Bandelier Tuff, Qbog (725–736 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 725 ft to 736 ft bgs. Qbog is composed of dense white pumice, which is less vesicular than the pumice fragments from the main Otowi Member, mixed with quartz and feldspar and abundant lithic fragments.

Puye Formation, Tpf (736–1397 ft bgs)

Puye Formation volcaniclastic sediments were encountered from 736 ft to the total borehole depth of 1397 ft bgs. The Puye Formation is characterized by abundant dacite fragments of variable types with minor feldspar and quartz grains. The types and abundance of dacite lithic fragments vary with depth. Abundant fine-grained dark gray dacite fragments dominate the lithic fragments in the 1230-ft to 1235-ft interval, whereas light to medium-gray dacite fragments are abundant in the lowermost part of the R-47 well.

5.2 Groundwater

Drilling at R-47 proceeded without any indications of groundwater until 1235 ft bgs, as noted by the drilling crew. The borehole was then advanced to the TD of 1397 ft bgs. The water level was 1307 ft bgs on September 11, 2014, before well installation. The DTW in the completed well was 1303.3 ft bgs on October 3, 2014. During development, pumping rates were variable between approximately 3 gallons per minute (gpm) and 15 gpm, depending on depth placement of the pump.

Figure 5.2-1 presents a water table elevation map for the regional aquifer in the area of R-47.

6.0 BOREHOLE LOGGING

On August 1, 2014, a borehole video survey was recorded from surface to 828.5 ft, and natural gamma ray and induction logs were run from surface to 838.5 ft bgs. A natural gamma ray log was recorded on September 11, 2014, inside the 12-in.-diameter casing from 680 ft to 1397 ft bgs after the borehole was advanced to TD. Logging was conducted using Laboratory logging equipment and staff. The video logs are provided on DVD as Appendix E of this report.

7.0 WELL INSTALLATION OF R-47 MONITORING WELL

The R-47 well was installed between September 14 and September 29, 2014.

7.1 Well Design

The R-47 well was designed in accordance with the Consent Order and New Mexico Environment Department– (NMED-) approved the final well design before it was installed (Appendix D). The well was designed with a screened interval between 1322 ft and 1342 ft bgs to monitor the groundwater quality near the top of the regional aquifer within the Puye Formation.

7.2 Well Construction

Decontamination of the stainless-steel well casing, screens, and tremie pipe, along with mobilization of the Pulstar work over rig and initial well construction materials to the site, took place from September 12 to 14, 2014.

The R-47 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 two 10-ft lengths of 5.0-in.-I.D. rod-based 0.040-in. wire-wrapped screens to make up the 20-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.-diameter steel tremie pipe was used to deliver backfill and annular fill materials downhole during well construction. A short length of 16-in.-diameter (7.5-ft casing and shoe, from 1137.1 ft to 1144.6 ft bgs) and 12-in.-diameter drill casing (3.6-ft casing and shoe, from 1392.0 ft to 1395.6 ft bgs) remain in the borehole. The 16-in.-diameter casing stub was encased in the upper bentonite seal and the 12-in.-diameter casing stub was encased in the bentonite backfill during well completion.

An 11.7-ft-long stainless-steel sump was placed below the bottom of the well screen. The well casing was started into the borehole on September 14 at 1000 h. The well casing was hung by wireline with the bottom at 1355.0 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 annular materials began on September 16 after the bottom of the borehole was measured at 1396.1 ft bgs (approximately 0.9 ft of slough had accumulated in the borehole). The bentonite backfill was installed between September 16 and 18 from 1348.1 ft to 1396.1 ft bgs using 42.4 ft^3 of 3/8-in. bentonite chips.

The filter pack was installed between September 18 and 19 from 1317.2 ft to 1348.1 ft bgs using 43.3 ft^3 of 10/20 silica sand. The actual volume of filter pack sand was 94% more than the calculated volume and is probably the result of an oversized borehole caused by sloughing in the unconsolidated Puye Formation. The filter pack was surged to promote compaction. The fine sand collar was installed above the filter pack from 1314.9 ft to 1317.2 ft bgs using 2.5 ft^3 of 20/40 silica sand. Table 7.2-1 presents the calculated and actual volumes of annular fill materials used at well R-47

From September 19 to 28, the upper bentonite seal was installed from 75.3 ft to 1314.9 ft bgs using 2887.9 ft^3 of 3/8-in. bentonite chips. On September 29, a cement seal was installed from 3.0 ft to 75.3 ft bgs. The cement seal used 307.5 ft^3 of Portland Type I/II/V cement. This volume exceeded the calculated volume of 281.8 ft^3 by 9% and is probably from cement loss to the near-surface formations.

Operationally, well construction proceeded smoothly, 12 h/d, 7 d/wk from September 14 to 17 and 24 h/d, 7 d/wk from September 18 to 29, 2014.

8.0 POST-INSTALLATION ACTIVITIES

Following well installation at R-47, the well was developed and aquifer pumping tests were conducted. The wellhead and surface pad were constructed, a geodetic survey was performed, and a dedicated sampling system was installed. Site-restoration activities will be completed following the final disposition of containerized drill cuttings and groundwater, per the NMED-approved waste-disposal decision trees.

8.1 Well Development

The well was developed between October 1 and 8, 2014. Initially, the screened interval was swabbed and bailed to remove formation fines in the filter pack and well sump. Bailing continued until water clarity visibly improved. Final development was then performed with a submersible pump.

The swabbing tool used 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 155 gal. of groundwater was removed during bailing activities.

After bailing, a 10-horsepower (hp), 4-in. Berkeley submersible pump was installed in the well for the final stage of well development. The pump was then used to purge the well sump on October 4. The screened interval was pumped from bottom to top in 2-ft increments each day from October 4 to October 7. During the October 4 to October 8 night shifts, the pump intake was set at 1339 ft bgs for purging. Approximately 58,614 gal. of groundwater was purged with the submersible pump during well development.

Total Volumes of Introduced and Purged Water

During drilling, approximately 6900 gal. of potable water was added below the surface of the regional aquifer at approximately 1300 ft bgs. An additional 22,200 gal. was added during installation of the screened interval filter pack. In total, approximately 29,100 gal. of potable water was introduced to the borehole within the regional aquifer during project activities.

Approximately 58,769 gal. of groundwater was purged at R-47 during well development activities. Another 8481 gal. was purged during aquifer testing. Total groundwater purged during post-installation activities was 67,250 gal.

8.1.1 Well Development Field Parameters

During the pumping stage of well development, turbidity, temperature, pH, dissolved oxygen (DO), oxidation-reduction potential (ORP), and specific conductance were measured. The required TOC and turbidity values for adequate well development are less than 2.0 ppm and less than 5 nephelometric turbidity units (NTU), respectively.

Field parameters were measured by collecting aliquots of groundwater from the discharge pipe with the use of a flow-through cell. The final parameters at the end of well development were pH of 8.03, temperature of 15.89ºC, specific conductance of 142 µS/cm, and turbidity of 43.8 NTU. Effervescence

was noted by field personnel throughout well development. Table B-2.2-1 in Appendix B shows field parameters and purge volumes measured during well development.

During the 24-h aquifer test, turbidity values decreased to the final recorded value of 8.4 NTU, near the target turbidity of 5 NTU.

8.2 Aquifer Testing

Aquifer pumping tests were conducted at R-47 between October 10 and 14, 2014. Several short-duration tests with short-duration recovery periods were performed on the first 2 d of testing. A 24-h pump test with the pump intake at 1326.7 ft bgs, followed by a 24-h recovery period, completed the testing of the screened interval. The average pumping rate for the 24-h test was 5.46 gpm.

A 5-hp pump was used for the aquifer tests. A total of approximately 8481 gal. of groundwater was purged during aquifer testing. Turbidity, temperature, pH, DO, ORP, and specific conductance were measured during the 24-h test. Measured parameters are presented in Appendix B. The R-47 aquifer test results and analysis are presented in Appendix C.

8.3 Dedicated Sampling System Installation

The dedicated sampling system for R-47 was installed on November 19 and 20, 2014. The pumping system utilizes an environmentally retrofitted 4-in. 5-hp Grundfos submersible pump set near the top of the screened interval. The pump column is constructed of 1-in.-diameter threaded/coupled passivated stainless-steel pipe. A weep hole was installed at the bottom of the uppermost pipe joint to protect the pump column from freezing. To measure water levels in the well, two 1-in.-I.D. schedule 80 polyvinyl chloride (PVC) pipes have been installed to sufficient depth to set a dedicated transducer and to provide access for manual water-level measurements. The PVC transducer tubes are equipped with 9-in. sections of 0.010-in. slot screen with a threaded end cap on the bottom of each tube. An In-Situ Level Troll 500 30-psig transducer is installed in one of the PVC tubes to monitor the water level in the well's screened interval.

Sampling system details for R-47 are presented in Figure 8.3-1a. Figure 8.3-1b presents technical notes for the well. Figure 8.3-1c presents a performance curve for the submersible pump installed.

8.4 Wellhead Completion

A reinforced concrete surface pad, 10 ft × 10 ft × 10 in. thick, was installed at the R-47 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.-I.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 October 31, 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-47 monitoring well.

8.6 Waste Management and Site Restoration

Waste generated from the R-47 project included drilling fluids, purged groundwater, drill cuttings, decontamination water, and contact waste. A summary of the waste characterization samples collected during drilling, well construction and development of the R-47 well is presented in Table 8.6-1.

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

Fluids produced during drilling, well development, and aquifer testing 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 the drilling fluids are hazardous/nonradioactive or mixed low-level waste, the drilling fluids will be disposed of at an authorized facility.

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. Characterization of contact waste will be based upon acceptable knowledge, pending analyses of the waste samples collected from the drill cuttings, purge 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, and backfilling and regrading the containment area, as appropriate.

9.0 DEVIATIONS FROM PLANNED ACTIVITIES

Drilling, sampling, and well construction at R-47 were performed as specified in the approved “Drilling Plan for Regional Aquifer Well R-47” (LANL 2012, 232340; NMED 2012, 521583).

10.0 ACKNOWLEDGMENTS

Boart Longyear drilled and installed the R-47 monitoring well.

David C. Schafer designed, implemented, and analyzed the aquifer tests.

TerranearPMC provided oversight for 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), November 2012. "Drilling Work Plan for Regional Aquifer Well R-47," Los Alamos National Laboratory document LA-UR-12-26098, Los Alamos, New Mexico. (LANL 2012, 232340)

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)

NMED (New Mexico Environment Department), November 29, 2012. "Approval with Modifications, Drilling Work Plan for Regional Aquifer Well R-47," New Mexico Environment Department letter to P. Maggiore (DOE-LASO) and J.D. Mousseau (LANL) from J.E. Kieling (NMED-HWB), Santa Fe, New Mexico. (NMED 2012, 521583)

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)

TerranearPMC, July 2014. "Field Implementation Plan for Regional Aquifer Well R-47," plan prepared for Los Alamos National Laboratory, Los Alamos, New Mexico. (TerranearPMC 2014, 262888)

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.

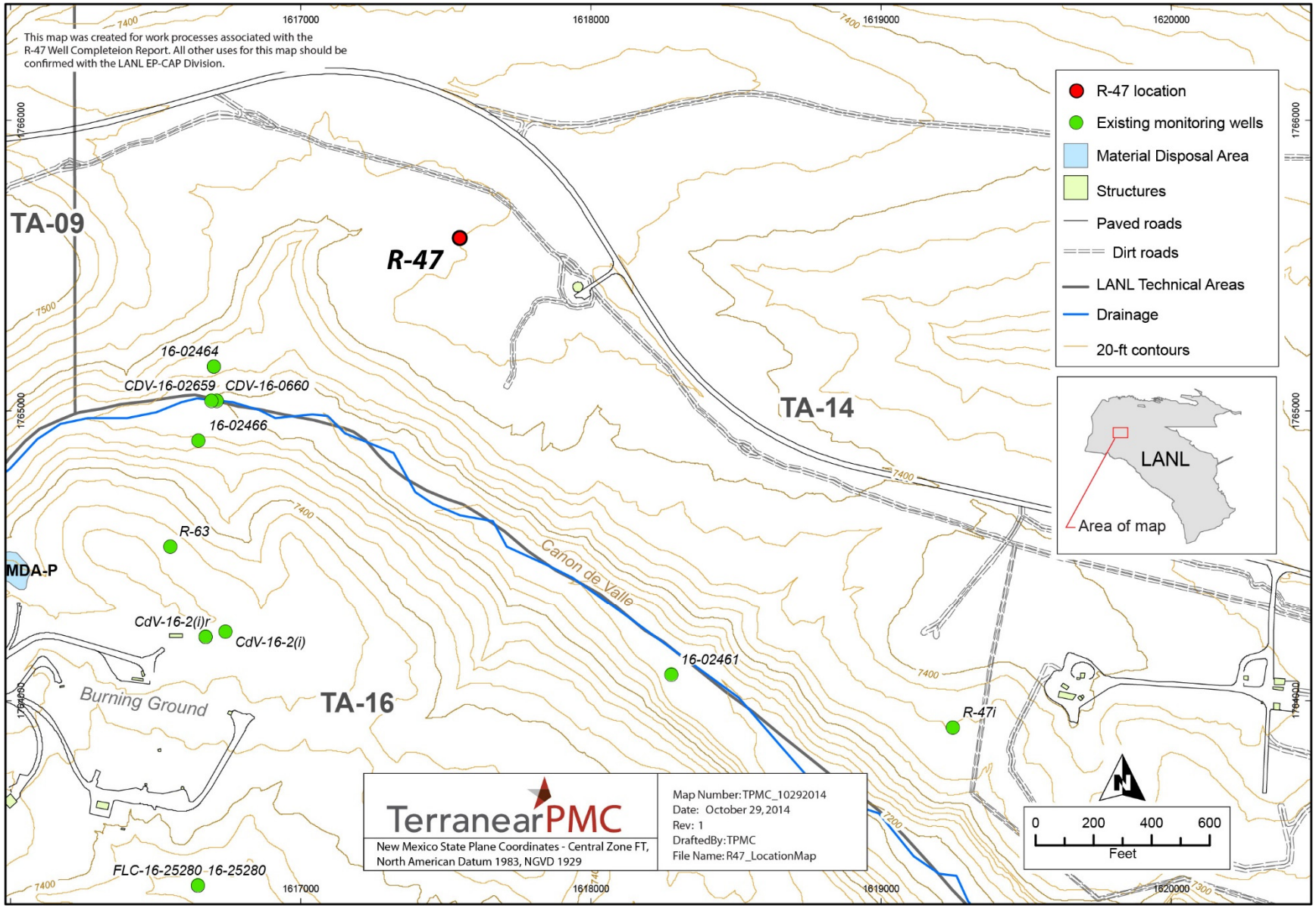


Figure 1.0-1 Location of monitoring well R-47

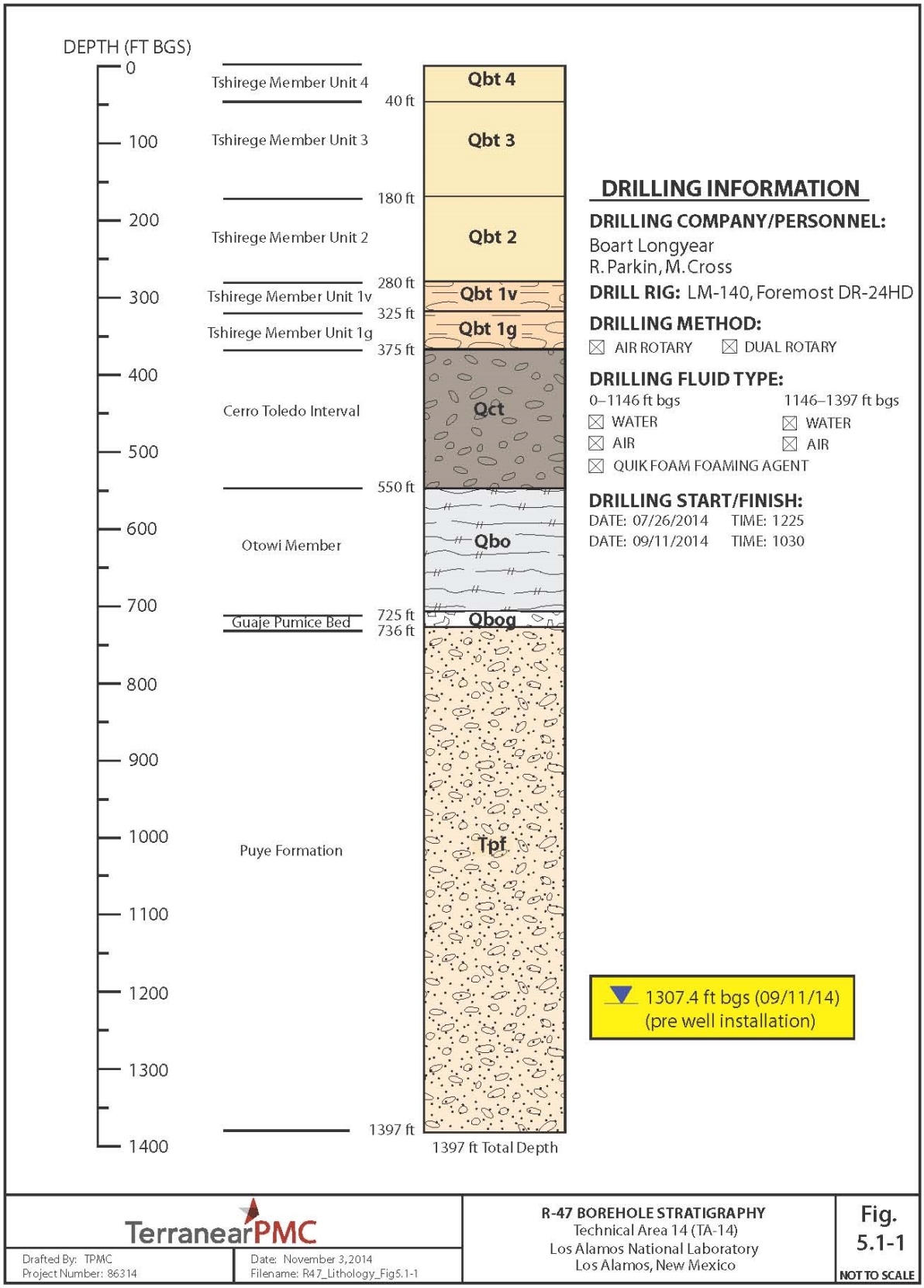


Figure 5.1-1 Monitoring well R-47 borehole stratigraphy

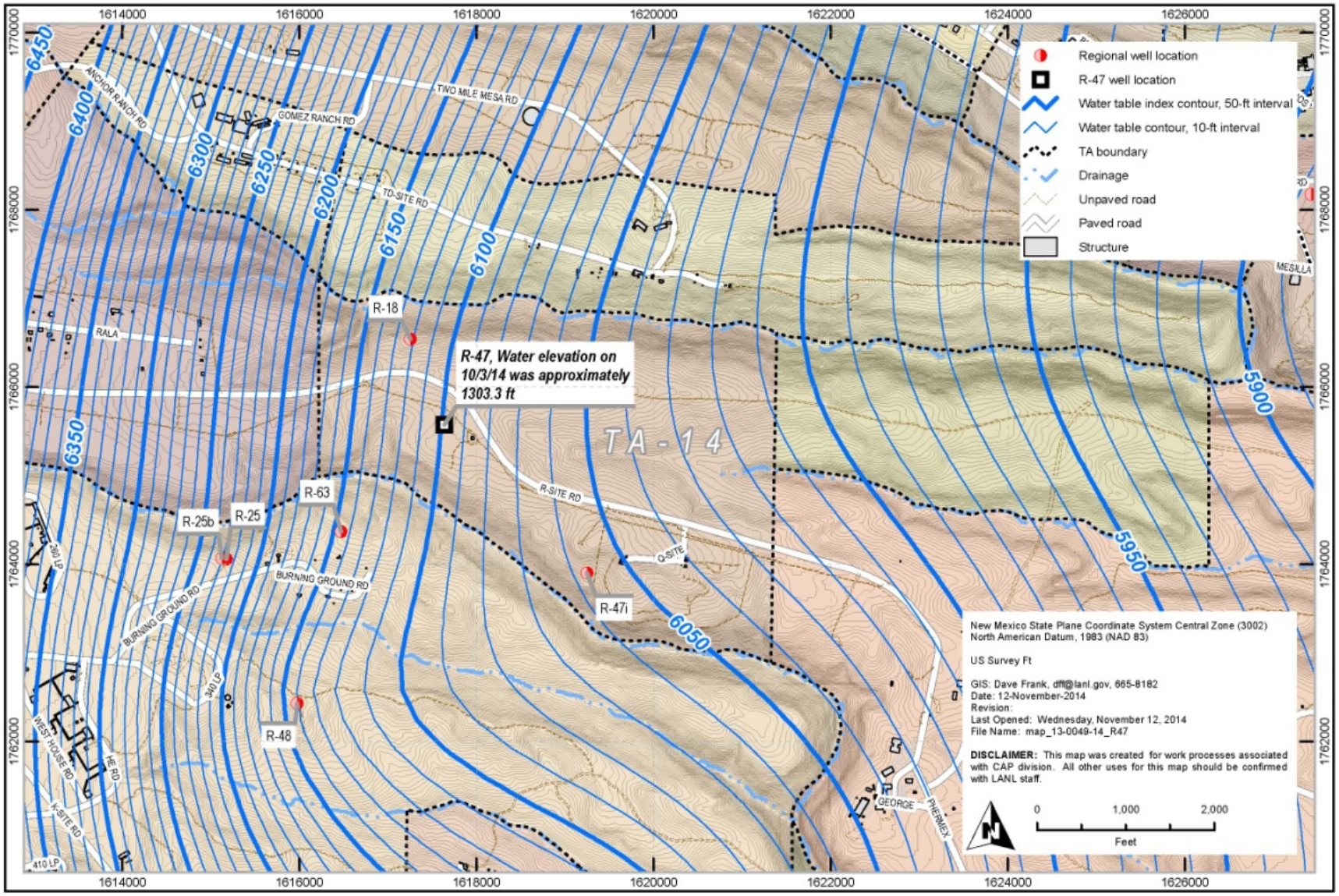


Figure 5.2-1 Regional aquifer groundwater elevations

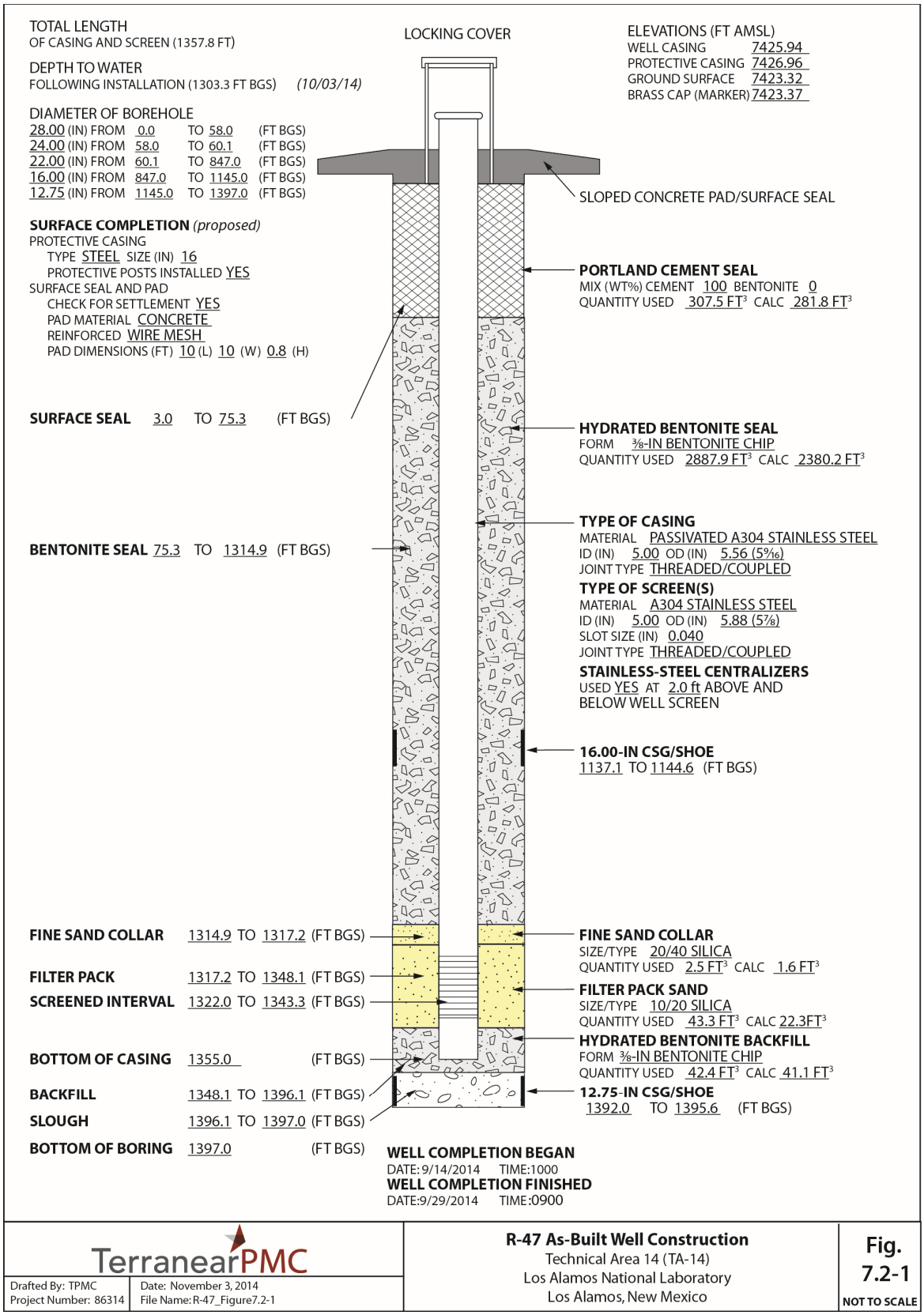


Figure 7.2-1 Monitoring well R-47 as-built well construction diagram

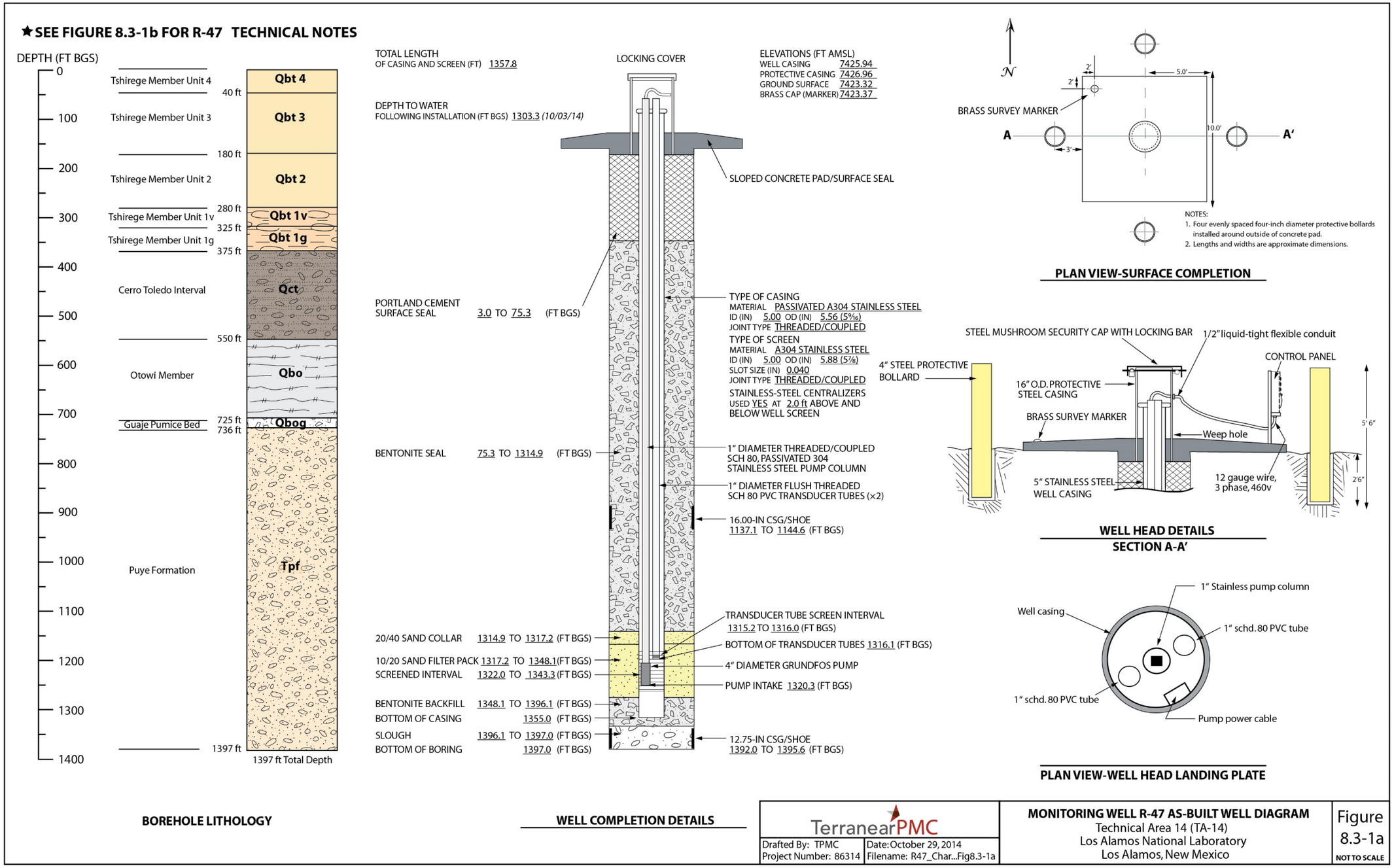


Figure 8.3-1a Monitoring well R-47 as-built diagram with borehole lithology and technical well completion details

R-47 TECHNICAL NOTES:

SURVEY INFORMATION*

Brass Marker

Northing:	1765581.72 ft
Easting:	1617641.36 ft
Elevation:	7423.37 ft AMSL

Well Casing (top of stainless steel)

Northing:	1765577.29 ft
Easting:	1617641.59 ft
Elevation:	7425.94 ft AMSL

BOREHOLE GEOPHYSICAL LOGS

LANL: Natural Gamma Ray, Induction

DRILLING INFORMATION

Drilling Company
Boart Longyear

Drill Rig
LM-140, Foremost DR-24HD

Drilling Methods
Dual Rotary
Fluid-assisted air rotary, Foam-assisted air rotary

Drilling Fluids
Air, potable water, AQF-2 Foam (to 1146 ft bgs)

MILESTONE DATES

Drilling

Start:	07/26/2014
Finished:	09/11/2014

Well Completion

Start:	09/14/2014
Finished:	09/29/2014

Well Development

Start:	10/01/2014
Finished:	10/08/2014

WELL DEVELOPMENT

Development Methods
Performed swabbing, bailing, and pumping
Total Volume Purged: 58,769 gal.

Parameter Measurements (Final)

pH:	8.03
Temperature:	15.89˚C
Specific Conductance:	142.0 µS/cm
Turbidity:	43.8 (8.8 at end of aquifer testing) NTU

AQUIFER TESTING

Constant Rate Pumping Test

Water Produced:	8,481 gal.
Average Flow Rate:	5.46 gpm
Performed on:	10/10–14/2014

DEDICATED SAMPLING SYSTEM

Pump (Shrouded)
Make: Grundfos
Model: 10S50-58
S/N: A09002758-P11441388
8 U.S. gpm at 1300 ft bgs
Environmental retrofit

Motor
Make: Franklin Electric
Model: 2343278602
S/N: 14C14-10-007950
5 hp, 3-phase

Pump Column
1.0-in. threaded/coupled schd. 80,
ASTM passivated A304 stainless steel tubing

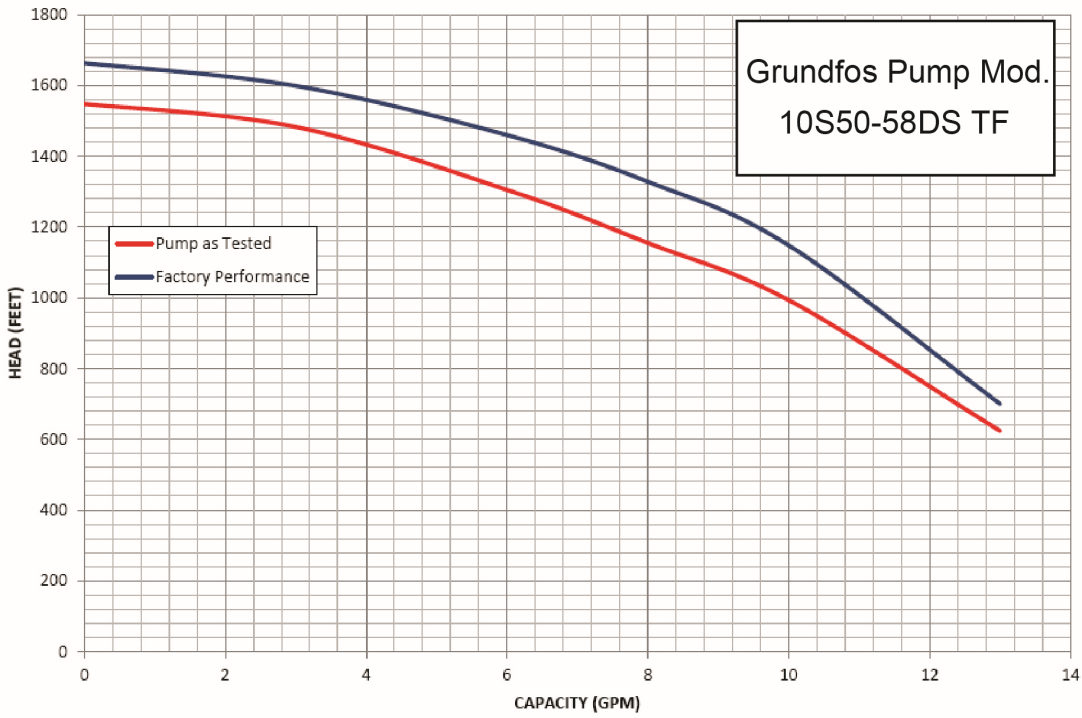
Transducer Tubes
2 × 1.0-in. flush threaded schd. 80 PVC tubing
0.010-in. slot screens at 1315.2–1316.0 ft bgs

Transducer
Make: In-Situ, Inc.
Model: Level TROLL 500
30 psig range (vented)
S/N: 390747

NOTES:
* Coordinates based on New Mexico State Plane Grid Coordinates, Central Zone (NAD83); Elevation expressed in feet amsl using the National Geodetic Vertical Datum of 1929.

TerranearPMC	R-47 TECHNICAL NOTES	Fig. 8.3-1b
Drafted By: TPMC Project Number: 86314	Date: October 29, 2014 Filename: R47_TechnicalNotes_Fig8.3-1b	Technical Area 14 (TA-14) Los Alamos National Laboratory Los Alamos, New Mexico	NOT TO SCALE

Figure 8.3-1b As-built technical notes for monitoring well R-47



TerranearPMC		R-47 DEDICATED PUMP PERFORMANCE CURVE Technical Area 14 (TA-14) Los Alamos National Laboratory Los Alamos, New Mexico	Fig. 8.3-1c NOT TO SCALE
Drafted By: TPMC Project Number: 86314	Date: November 3, 2014 Filename: R47_PumpCurves_Fig8-3-1c		

Figure 8.3-1c Pump curves for monitoring well R-47

Table 3.1-1
Fluid Quantities Used during R-47 Drilling and Well Construction

Date	Depth Interval (ft bgs)	Water (gal.)	Cumulative Water (gal.)	Quick Foam (gal.)	Cumulative Quick Foam (gal.)
Drilling					
7/26/14	0–58	0	0	0	0
7/27/14	58–138	5700	5700	39	39
7/28/14	138–307	8400	14,100	56	95
7/29/14	307–748	11,700	25,800	87	182
7/30/14	748–847	7800	33,600	65	247
8/22/14	847–926	3912	37,512	24	271
8/23/14	926–1086	4200	41,712	26	297
8/24/14	1086–1145	2850	44,562	14.25	311.25
8/29/14	1145–1165	1000	45,562	0	311.25
8/30/14	1165–1275	3150	48,712	0	311.25
8/31/14	1275–1295	1500	50,212	0	311.25
9/1/14	1295–1350	3000	53,212	0	311.25
9/2/14	1350–1377	1200	54,412	0	311.25
9/3/14	1377–1397	900	55,312	0	311.25
9/10/14	1308–1397	1800	57,112	0	311.25
Well Construction					
9/16/14	1396–1387	2500	2500	n/a*	n/a
9/17/14	1387–1364	5100	7600	n/a	n/a
9/18/14	1364–1318	6140	13,740	n/a	n/a
9/19/14	1318–1281	8460	22,200	n/a	n/a
9/20/14	1281–1147	11,325	33,525	n/a	n/a
9/25/14	1147–1065	385	33,910	n/a	n/a
9/26/14	1065–776	1950	35,860	n/a	n/a
9/27/14	776–242	5865	41,725	n/a	n/a
9/28/14	242–25	2680	44,405	n/a	n/a
9/29/14	25–3	450	44,855	n/a	n/a
Total Water Volume (gal.)					
R-47	101,967				

*n/a = Not applicable. Foam use terminated at 1145 ft bgs during drilling; none used during well construction.

Table 4.2-1
Summary of Groundwater Screening Samples Collected during Well Development and Aquifer Testing of Well R-47

Location ID	Sample ID	Date Collected	Collection Depth (ft bgs)	Sample Type	Analysis
Well Development					
R-47	CACV-14-85683	10/05/14; 1730h	1339	Groundwater, Pumped	TOC
R-47	CACV-14-85684	10/06/14; 0605h	1339	Groundwater, Pumped	TOC
R-47	CACV-14-85685	10/06/14; 1730h	1321	Groundwater, Pumped	TOC
R-47	CACV-14-85686	10/07/14; 0600h	1339	Groundwater, Pumped	TOC
R-47	CACV-14-85687	10/07/14; 1730h	1321	Groundwater, Pumped	TOC
R-47	CACV-14-85688	10/08/14; 0615h	1321	Groundwater, Pumped	TOC
Aquifer Testing					
R-47	CACV-14-85675	10/13/14; 2000h	1327	Groundwater, Pumped	RDX
R-47	CACV-14-85676	10/14/14; 0755h	1327	Groundwater, Pumped	RDX

Table 7.2-1
R-47 Monitoring Well Annular Fill Materials

Material	Volume (ft^3)
Upper surface seal: cement slurry	307.5
Upper bentonite seal: bentonite chips	2887.9
Fine sand collar: 20/40 silica sand	2.5
Filter pack: 10/20 silica sand	43.3
Backfill: bentonite chips	42.4

Table 8.5-1
R-47 Survey Coordinates

Identification	Northing	Easting	Elevation
R-47 brass cap embedded in pad	1765581.72	1617641.36	7423.37
R-47 ground surface near pad	1765589.45	1617626.14	7423.32
R-47 top of stainless-steel well casing	1765577.29	1617641.59	7425.94
R-47 top of 16-in. protective casing	1765577.85	1617641.24	7426.96

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 Sampling System Installation at R-47

Location ID	Sample ID	Date Collected	Description	Sample Type
R-47	WST14-14-86622	10/8/14	Drill fluids (filtered sample)	Liquid
R-47	WST14-14-86623	10/8/14	Drill fluids (unfiltered sample)	Liquid
R-47	WST14-14-86624	10/8/14	Drill fluids (field duplicate)	Liquid
R-47	WST14-14-86625	10/8/14	Drill fluids (field trip blank)	Liquid
R-47	WST14-14-86661	10/8/14	Drill cuttings (waste sample)	Solids
R-47	WST14-14-86662	10/8/14	Drill cuttings (field trip blank)	Solids
R-47	WST14-14-87517	Pending	Decon fluid (filtered sample)	Liquid
R-47	WST14-14-87518	Pending	Decon fluid (unfiltered sample)	Liquid
R-47	WST14-14-87519	Pending	Decon fluid (field duplicate)	Liquid
R-47	WST14-14-87520	Pending	Decon fluid (field trip blank)	Liquid
R-47	WST14-15-90434	Pending	Development water (filtered sample)	Liquid
R-47	WST14-15-90456	Pending	Development water (unfiltered sample)	Liquid
R-47	WST14-15-90458	Pending	Development water (field duplicate)	Liquid
R-47	WST14-15-90459	Pending	Development water (field trip blank)	Liquid
R-47 (at PLY*)	WST14-14-87521	Pending	Decon w/Steel Brite (filtered sample)	Liquid
R-47 (at PLY)	WST14-14-87522	Pending	Decon w/Steel Brite (unfiltered sample)	Liquid
R-47 (at PLY)	WST14-14-87523	Pending	Decon w/Steel Brite (field duplicate)	Liquid
R-47 (at PLY)	WST14-14-87523	Pending	Decon w/Steel Brite (field trip blank)	Liquid

*PLY = Pajarito Laydown Yard.

Appendix A

Borehole R-47 Lithologic Log

BOREHOLE IDENTIFICATION (ID): R-47	**TECHNICAL AREA (TA):** 14	**PAGE:** 2 of 13
DRILLING COMPANY: Boart Longyear Company	**START DATE/TIME:** 7/26/14; 1225	**END DATE/TIME:** 9/11/14; 1030
DRILLING METHOD: Air Rotary/ Dual Rotary	**MACHINE**: LM 140/Foremost DR-24 HD	**SAMPLING METHOD:** Grab
GROUND ELEVATION: 7423.32 ft amsl		**TOTAL DEPTH:** 1397 ft
DRILLERS: R. Parkin, M. Cross	**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) moderately welded, crystal-bearing tuff with lithic fragments. 0'-5' WR: 60% powdered ash flow tuff and welded tuff fragments; 25% quartz and sanidine crystals; 15% rhyolitic and dacitic lithic clasts. +10F: 80% crystal-bearing, lithic poor ash flow tuff fragments; 10% quartz and sanidine crystals; 10% dacitic and rhyolitic lithic clasts. +35F: 95% quartz and sanidine crystals; <5% tuff fragments; trace lithic clasts.	Qbt 4	Note: Drill cuttings for descriptive analysis were collected at 5-ft intervals from ground surface to borehole TD at 1397 ft bgs. Unit 4 of the Tshirege Member of the Bandelier Tuff (Qbt 4), encountered from 0 to 40 ft bgs, is 40 ft thick. The Qbt 4/Qbt 3 contact, estimated at 5 ft bgs, is based on natural gamma logging.
5-20	Rhyolitic Tuff—pale orange (5YR 8/4) moderately welded, crystal-bearing tuff with minor lithic fragments 5'– 20' WR: 85% powdered ash flow tuff and welded tuff fragments; 10% quartz and sanidine crystals; 5% rhyolitic and dacitic lithic clasts. +10F: 90% crystal-bearing, lithic poor ash flow tuff fragments; 7% dacitic lithic fragments; 3% quartz and sanidine crystals. +35F: 97% quartz and sanidine crystals; <3% tuff fragments; trace lithic clasts.	Qbt 4	
20-40	Rhyolitic Tuff—pale orange (5YR 8/4) poorly to moderately welded, crystal-rich tuff with minor lithic fragments 20'-40' WR: 95% powdered ash flow tuff and minor crystal-rich welded tuff fragments; <5% quartz and sanidine crystals; trace lithic clasts. +10F: 85-95% crystal-rich, lithic poor ash flow tuff fragments; 0-15% dacitic and rhyolitic lithic fragments;0-3% quartz crystals; 0-2% broken quartzite clasts (in 10'-15' interval. likely from pad construction); trace of lithic fragments. +35F: 97% quartz and sanidine crystals; <3% tuff fragments; trace lithic clasts.	Qbt 4	

DEPTH (ft bgs)	LITHOLOGY	LITHOLOGIC SYMBOL	NOTES
40-45	**UNIT 3 OF THE TSHIREGE MEMBER OF THE BANDELIER TUFF:** Rhyolitic Tuff—very pale purple (5RP 8/1) to white (N9), moderately welded, crystal-bearing tuff with minor lithic fragments 40'-45' WR: 95% powdered ash flow tuff and minor crystal-rich welded tuff fragments; <5% quartz and sanidine crystals; trace lithic clasts. +10F: 95% crystal-rich, ash flow tuff fragments; 5% quartz crystals. +35F: 85% quartz and sanidine crystals; <15% rhyolite fragments; trace tuff fragments.	Qbt 3	Unit 3 of the Tshirege Member of the Bandelier Tuff (Qbt 3), encountered from 40 to 180 ft bgs, is approximately 140 ft thick.
45-60	Rhyolitic Tuff—very pale purple (5RP 8/1) to white (N9), moderately welded, crystal-rich tuff. 45'-60' WR: 90-95% powdered ash flow tuff and minor crystal-rich welded tuff fragments; 5-10% quartz and sanidine crystals. +10F: 30-60% crystal-rich, ash flow tuff fragments; 40-70% euhedral quartz crystals. +35F: 95-98% quartz and sanidine crystals; 2-5% tuff fragments.	Qbt 3	
60-80	Rhyolitic Tuff—white to light gray (N9 to N7), poorly welded, crystal-rich tuff. 60'-80' WR/+10F: 80-95% euhedral quartz and sanidine phenocrysts; 5-20% crystal rich tuff fragments. +35F: 99-100% quartz and sanidine crystals; trace tuff fragments; trace lithic clasts.	Qbt 3	
80-100	Rhyolitic Tuff—gray (N6 to N7), strongly welded, crystal-rich tuff. 80'-100' WR: 60-80% tuff fragments; 20-40% quartz and sanidine crystals. +10F: 80-95% crystal-rich tuff fragments; 5-20% euhedral quartz crystals. +35F: 60-80% quartz and sanidine crystals; 20-40% rhyolitic tuff fragments.	Qbt 3	
100-105	Rhyolitic Tuff—gray (N6) to pale reddish brown(10R 7/2), strongly welded, crystal-rich tuff. 100'-105' WR: 80% tuff fragments; 20% quartz and sanidine crystals. +10F: 90% crystal-rich tuff fragments; 10% euhedral quartz crystals. +35F: 90% quartz and sanidine crystals; 10% rhyolitic tuff fragments	Qbt 3	

DEPTH (ft bgs)	LITHOLOGY	LITHOLOGIC SYMBOL	NOTES
105-130	Rhyolitic Tuff—gray (N6) to pale reddish brown(10R 7/2), moderately welded, crystal-rich tuff. 105'-130' WR: 55-70% quartz and sanidine crystals; 30-40% tuff fragments; trace lithic fragments; trace pumice clasts. +10F: 70-90% euhedral quartz and sanidine crystals; 10-30% tuff fragments; trace lithic fragments. +35F: 95-99% quartz and sanidine crystals; 1-5% rhyolitic tuff fragments; trace lithic fragments	Qbt 3	
130-180	Rhyolitic Tuff—gray (N6) to pale purple (10P 7/2), moderately welded, crystal-rich tuff. 130'-176' WR: 85-95% quartz and sanidine crystals; 5-15% tuff fragments; trace lithic fragments; trace pumice clasts. +10F: 85-95% euhedral quartz and sanidine crystals; 5-10% tuff fragments; 0-5% lithic fragments. +35F: 98-99% quartz and sanidine crystals; 1-2% rhyolitic tuff fragments; trace lithic fragments	Qbt 3	The Qbt 3/Qbt 2 contact, estimated at 180 ft bgs, is based on abrupt slowing of penetration rate during drilling.
180-190	**UNIT 2 OF THE TSHIREGE MEMBER OF THE BANDELIER TUFF** Rhyolitic Tuff—gray (N6) to pale purple gray (5PB 6/2), strongly welded, crystal-rich tuff. 176'-190' WR: 55-70% quartz and sanidine crystals; 30-45% tuff fragments; trace lithic fragments; trace pumice clasts. +10F: 60-70% welded tuff fragments; 30-40% euhedral quartz and sanidine crystals. +35F: 60-70% quartz and sanidine crystals; 30-40% rhyolitic tuff fragments; trace lithic fragments	Qbt 2	Unit 2 of the Tshirege Member of the Bandelier Tuff (Qbt 2), encountered from 180 to 280 ft bgs, is approximately 100 ft thick.
190-235	Rhyolitic Tuff—gray (N6) to pale orange (10YR 8/2), strongly welded, crystal-rich tuff. 190'-235' WR: 60-70% strongly welded crystal-rich tuff fragments; 30-40% quartz and sanidine crystals; trace basaltic and dacitic lithic fragments; trace devitrified pumice clasts. +10F: 70-80% quartz and biotite bearing tuff fragments; 20-30% euhedral quartz and sanidine crystals. +35F: 40-70% quartz and sanidine crystals (increasing down section); 30-60% rhyolitic tuff fragments; trace lithic fragments	Qbt 2	
235-245	Rhyolitic Tuff—gray (N6) to pale orange (10YR 8/2), strongly welded, crystal-rich tuff. 235'-245' WR: 70-90% strongly welded crystal-rich tuff fragments; 10-30% quartz and sanidine crystals. +10F: 90% quartz and biotite bearing tuff fragments; 10% euhedral quartz and sanidine crystals. +35F: 70-90% rhyolitic tuff fragments; 10-30% quartz and sanidine crystals	Qbt 2	

DEPTH (ft bgs)	LITHOLOGY	LITHOLOGIC SYMBOL	NOTES
245-265	Rhyolitic Tuff—light gray (N7) to pale orange (10YR 8/2), poorly to moderately welded, crystal-rich tuff. 245'-265' WR: 40-80% crystal-rich tuff fragments; 20-60% quartz and sanidine crystals. +10F: 70-80% rhyolitic tuff fragments; 20-30% euhedral quartz and sanidine crystals. +35F: 50-80% quartz and sanidine crystals; 20-50% rhyolitic tuff fragments.	Qbt 2	
265-280	Rhyolitic Tuff—light gray (N7) to pale orange (10YR 8/2), poorly to moderately welded, crystal-rich tuff. 265'-280' WR: 40-70% quartz and sanidine crystals; 30-60% crystal-rich tuff fragments. +10F: 70-80% rhyolitic tuff fragments; 20-30% euhedral quartz and sanidine crystals. +35F: 80-95% quartz and sanidine crystals; 5-20% rhyolitic tuff fragments.	Qbt 2	The Qbt 2/Qbt 1v contact, estimated at 280 ft bgs, is based on change in penetration rate while drilling.
280-290	**UNIT 1v OF THE TSHIREGE MEMBER OF THE BANDELIER TUFF** Rhyolitic Tuff—light gray (N7), poorly welded, crystal-rich tuff with minor glassy pumice. 280'-290' WR: 60-70% quartz and sanidine crystals; 30-40% crystal-rich, vitric pumice-bearing tuff fragments. +10F: 40-60% rhyolitic tuff fragments; 40-60% euhedral quartz and sanidine crystals; trace vitric pumice clasts. +35F: 80-90% quartz and sanidine crystals; 10-20% rhyolitic tuff fragments.	Qbt 1v	Unit 1v of the Tshirege Member of the Bandelier Tuff (Qbt 1v), encountered from 280 to 325 ft bgs, is approximately 45 ft thick.
290-300	Rhyolitic Tuff—light gray (N7), poorly welded, crystal-rich tuff with minor glassy pumice. 290'-300' WR: 75-85% quartz and sanidine crystals; 15-25% crystal-rich, vitric pumice-bearing tuff fragments. +10F: 60-80% euhedral quartz and sanidine crystals; 20-40% rhyolitic tuff fragments. +35F: 90-95% quartz and sanidine crystals; 5-10% rhyolitic tuff fragments.	Qbt 1v	
300-305	Rhyolitic Tuff—light gray (N7), moderately welded, crystal-rich tuff. 300'-305' WR: 85% crystal-rich tuff fragments; 15% quartz and sanidine crystals. +10F: 95% rhyolitic tuff fragments; 5% quartz and sanidine crystals;. +35F: 95% quartz and sanidine crystals; 5% rhyolitic tuff fragments.	Qbt 1v	

DEPTH (ft bgs)	LITHOLOGY	LITHOLOGIC SYMBOL	NOTES
305-325	Volcaniclastic Sediments—silt to sand size angular quartz grains with orange oxidation staining. Angular rhyolitic tuff and pumice clasts and various volcaniclastic sediments. 305'– 325' WR/+10F: 75-90% silt to sand size angular quartz grains; 5-20% rhyolitic tuff clasts and pumices; 5-10% gray dacite and variegated rhyolite clasts up to 4mm. +35F: 90-98% silt to sand size angular quartz grains; 1-5% pumice fragments; 1-5% dacite and rhyolite grains.	Qbt 1v	The Qbt 1v/Qbt 1g contact, estimated at 325 ft bgs, is based on presence of glassy pumice fragments in tuff cuttings below contact.
325-340	**UNIT 1g OF THE TSHIREGE MEMBER OF THE BANDELIER TUFF** Volcaniclastic Sediments—silt to sand size angular quartz grains with orange oxidation staining. Angular rhyolitic tuff and pumice clasts and various volcaniclastic sediments. 325'– 340' WR/+10F: 70-85% silt to sand size angular quartz grains; 5-20% rhyolitic tuff clasts and pumices; 10-15% gray dacite and variegated rhyolite clasts up to 10mm. +35F: 90-98% silt to sand size angular quartz grains; 1-5% pumice fragments; 1-5% dacite and rhyolite grains.	Qbt 1g	Unit 1g of the Tshirege Member of the Bandelier Tuff (Qbt 1g), encountered from 325 to 375 ft bgs, is approximately 50 ft thick.
340-350	Volcaniclastic Sediments—silt to sand size angular quartz grains with orange oxidation staining. Angular rhyolitic tuff and pumice clasts and various volcaniclastic sediments. 340'– 350' WR/+10F: 70-85% clay to sand size angular quartz grains; 5-20% rhyolitic tuff clasts and pumices; 10-15% gray dacite and variegated rhyolite clasts up to 10mm. +35F: 90-98% silt to sand size angular quartz grains; 1-5% pumice fragments; 1-5% dacite and rhyolite grains.	Qbt 1g	
350-375	Volcaniclastic Sediments—silt to sand size angular quartz grains with orange oxidation staining, reworked white pumice clasts, and dacite and rhyolite clasts. 350'– 375' WR/+10F: 40-60% silt to sand size angular quartz grains; 10-40% pumice; 10-30% gray /red rhyolite, brown tuff, and gray dacite clasts up to 3mm. +35F: 50-70% angular quartz and sanidine grains; 10-30% gray /red rhyolite and gray dacite grains; 10-30% pumice.	Qbt 1g	The Qbt 1g/Qct contact, estimated at 375 ft bgs, is based on pumice abundance, color change due to oxidation staining and natural gamma logging.

DEPTH (ft bgs)	LITHOLOGY	LITHOLOGIC SYMBOL	NOTES
375-390	**CERRO TOLEDO INTERVAL** Volcaniclastic Sediments—silt to sand size angular quartz grains with orange oxidation staining, reworked white pumice clasts, and dacite and rhyolite clasts. 365'– 390' WR/+10F: 40-60% silt to sand size angular quartz grains; 10-40% pumice; 10-30% gray /red rhyolite, brown tuff, and gray dacite clasts up to 3mm. +35F: 50-70% angular quartz and sanidine grains; 10-30% gray /red rhyolite and gray dacite grains; 10-30% pumice.	Qct	The Cerro Toledo interval (Qct), encountered from 375 to 550 ft bgs, is approximately 175 ft thick.
390-415	Volcaniclastic Sediments—silt to sand size angular quartz grains with orange oxidation staining, reworked pumice clasts, and dacite and rhyolite clasts. 390'–415' WR/+10F: 30-50% pumice; 20-40% gray /red rhyolite, brown tuff, and gray dacite clasts; 10-40% silt to sand size angular quartz grains. +35F: 30-50% pumice; 10-40% angular quartz and sanidine grains; 10-40% gray /red rhyolite and gray dacite grains.	Qct	
415-435	Volcaniclastic Sediments—silt to sand size angular quartz grains with orange oxidation staining, brown to orange pumice clasts, and dacite and rhyolite clasts. 415'–435' WR/+10F: 30-50% pumice; 20-40% gray /red rhyolite, brown tuff, and gray dacite clasts; 10-40% silt to sand size angular quartz grains. +35F: 30-50% pumice; 10-40% angular quartz and sanidine grains; 10-40% gray /red rhyolite and gray dacite grains.	Qct	Note: the 415'-435' interval has much more orange oxidation staining than above.
435-470	Volcaniclastic Sediments— clay to sand size angular quartz grains with orange oxidation staining, brown to orange pumice clasts, and dacite and rhyolite clasts. 435'–470' WR/+10F: 20-50% pumice; 20-40% gray /red rhyolite, brown tuff, and gray dacite clasts; 20-40% clay to sand size angular quartz grains. +35F: 30-50% pumice; 10-40% angular quartz and sanidine grains; 10-40% gray /red rhyolite and gray dacite grains.	Qct	
470-480	No samples returned	Qct	

DEPTH (ft bgs)	LITHOLOGY	LITHOLOGIC SYMBOL	NOTES
480-505	Volcaniclastic Sediments— clay to sand size angular quartz grains with orange oxidation staining, brown to orange pumice clasts, and dacite and rhyolite clasts. 480'–505' WR/+10F: 20-50% pumice; 20-40% gray /red rhyolite, brown tuff, and gray dacite clasts; 20-40% clay to sand size angular quartz grains. +35F: 30-50% pumice; 10-40% angular quartz and sanidine grains; 10-40% gray /red rhyolite and gray dacite grains.	Qct	Note: the 480' to 490' interval has less oxidation of pumices than above.
505-550	Volcaniclastic Sediments— clay to sand size angular quartz grains with orange oxidation staining, brown to orange pumice clasts, and dacite and rhyolite clasts. 505'–550' WR/+10F: 30-60% gray dacite clasts with minor rhyolite clasts; 20-40% pumice; 20-30% clay to sand size angular quartz grains. +35F: 30-50% pumice; 10-40% gray /red rhyolite and gray dacite grains; 10-40% angular quartz and sanidine grains.	Qct	Note: this interval has more abundant dacitic clasts up to 20mm. The Qct/Qbo contact, estimated at 550 ft bgs, is based on observations while drilling and dominance of white pumice in cuttings below 550'.
550-570	**OTOWI MEMBER OF THE BANDELIER TUFF** Rhyolitic Tuff—pale orange (5YR 6/2) to white (N9), poorly welded, pumice- and lithic-rich tuff. 550'-570' WR/+10F: 40-70% white to orange pumice; 30-50% gray dacite or red-purple rhyolite lithic fragments; 5-20% quartz grains. +35F: 50-70% white to orange pumice; 10-40% quartz grains; 10-30% lithic fragments.	Qbo	The Otowi Member of the Bandelier Tuff (Qbo), encountered from 550 to 725 ft bgs, is approximately 175 ft thick.
570-575	No samples returned	Qbo	
575-625	Rhyolitic Tuff—white (N9), poorly welded, pumice- and lithic-rich tuff. 575'-625' WR/+10F: 40-70% white to orange pumice; 30-50% gray dacite or red-purple rhyolite lithic fragments; 5-20% quartz grains. +35F: 50-70% white to orange pumice; 10-40% quartz grains; 10-30% lithic fragments.	Qbo	
625-725	Rhyolitic Tuff—white (N9), poorly welded, pumice-rich tuff. 625'-725' WR/+10F: 60-80% white to orange pumice; 10-30% gray dacite or red-purple rhyolite lithic fragments; 5-20% quartz grains. +35F: 60-80% white to orange pumice; 10-35% quartz grains; <10% lithic fragments.	Qbo	The Qbo/Qbog contact, estimated at 725 ft bgs, is based on increase in abundance of pumice and increase pumice size in cuttings.

DEPTH (ft bgs)	LITHOLOGY	LITHOLOGIC SYMBOL	NOTES
725-736	**GUAJE PUMICE BED OF THE OTOWI MEMBER OF THE BANDELIER TUFF** Rhyolitic Tuff—white (N9), poorly welded, pumice-rich tuff. 725'-736' WR/+10F: 80-90% white to orange pumice; 10-20% gray dacite or red-purple rhyolite lithic fragments +35F: 80-90% white to orange pumice; 5-15% lithic fragments; 0-5% quartz grains.	Qbog	The Guaje Pumice Bed of the Otowi Member of the Bandelier Tuff (Qbog), encountered from 725 to 736 ft bgs, is approximately 11 ft thick. The Qbog/Tpf contact, estimated at 736 ft bgs, is based on volcaniclastic sediments in cuttings, drillers' observations, and natural gamma logging.
736-740	**PUYE FORMATION** Volcaniclastic Sediments—varicolored grains of dacite and rhyolite. 736– 740' WR/+10F: 40-70% angular to subangular grains of dacite and rhyolite; 30-60% white pumice clasts (likely falling from above); trace quartz grains. +35F: 40-80% dacite and rhyolite grains; 15-55% pumice clasts; <5% quartz grains.	Tpf	The Puye Formation (Tpf), encountered from 736 to 1397 ft bgs, is at least 661 ft thick.
740-760	Volcaniclastic Sediments—varicolored grains of dacite and rhyolite. 740– 760' WR/+10F/+35F: 80-90% angular to subangular grains of dacite and rhyolite; 10-20% devitrified white pumice clasts (possibly falling from above); trace quartz grains.	Tpf	
760-780	Volcaniclastic Sediments—varicolored grains of dacite and rhyolite. 760– 780' WR/+10F: 90-95% angular to subangular grains of dacite and rhyolite; 5-10% devitrified white pumice clasts; trace quartz grains. +35F: 90-95% subangular to subrounded volcaniclastic grains, mostly dacite with minor rhyolite; 5-10% white to orange pumice clasts; trace quartz grains.	Tpf	Note: grain size in the +35 seive fraction is finer than above and rounding has increased from mostly angular to mostly subangular.
780-845	Volcaniclastic Sediments—varicolored grains of dacite and rhyolite. 780– 845' WR/+10F: 95-100% angular to subangular grains of dacite and rhyolite; <5% devitrified white pumice clasts. +35F: 95-100% subangular to subrounded volcaniclastic grains, mostly dacite with minor rhyolite; <5% white to orange pumice clasts; trace quartz grains.	Tpf	.
845-860	Volcaniclastic Sediments—clasts of gray dacite and minor varicolored rhyolite. 845– 860' WR/+10F: 90-95% rounded to subrounded grains of dacite and minor rhyolite; 5-10% devitrified white pumice clasts; trace quartz grains. +35F: 90-95% subrounded volcaniclastic grains, mostly dacite with minor rhyolite; <5% devitrified pumice clasts; <5% quartz grains.	Tpf	Note: increased rounding in this section. Grain size is less than 5 mm from 845 to 850 ft and up to 20 mm from 850 to 860 ft.

DEPTH (ft bgs)	LITHOLOGY	LITHOLOGIC SYMBOL	NOTES
860-865	Volcaniclastic Sediments—clasts of gray dacite and minor varicolored rhyolite. 860– 865' WR/+10F: 95-100% angular to subangular grains of dacite and rhyolite; <5% devitrified white pumice clasts. +35F: 95-100% angular to subangular volcaniclastic grains, mostly dacite with minor rhyolite; <5% devitrified pumice clasts; trace quartz grains.	Tpf	
865-880	Volcaniclastic Sediments—clasts of gray dacite and minor varicolored rhyolite. 865– 880' WR/+10F: 95-100% angular grains of dacite and rhyolite up to 5 mm; <5% devitrified white pumice clasts. +35F: 95-100% angular to subangular volcaniclastic grains, mostly dacite with minor rhyolite; <5% devitrified pumice clasts; trace quartz grains.	Tpf	Note: decrease in grain size. Very angular grains may indicate clasts larger than 2 cm were broken into chips while drilling.
880-885	Volcaniclastic Sediments—clasts of gray dacite and minor varicolored rhyolite. 880– 885' WR/+10F: 95-100% angular to subangular grains of dacite and rhyolite up to 25 mm; <5% devitrified white pumice clasts. +35F: 95-100% angular to subangular volcaniclastic grains, mostly dacite with minor rhyolite; <5% devitrified pumice clasts; trace quartz grains.	Tpf	
885-895	Volcaniclastic Sediments—clasts of gray dacite and minor varicolored rhyolite. 885– 895' WR/+10F: 95-100% angular grains of dacite and rhyolite up to 15 mm; <5% devitrified white pumice clasts. +35F: 95-100% angular to subangular volcaniclastic grains, mostly dacite with minor rhyolite; <5% devitrified pumice clasts; trace quartz grains.	Tpf	
895-955	Volcaniclastic Sediments—clasts of gray dacite and minor varicolored rhyolite. 895– 955' WR/+10F: 95-100% angular grains of dacite, rhyolite, and ash flow tuff up to 30 mm; <5% devitrified white pumice clasts. +35F: 95-100% angular to subangular volcaniclastic grains, mostly dacite with minor rhyolite; <5% devitrified pumice clasts; trace quartz grains.	Tpf	Note: Increase in grain size in this section.
955-965	Volcaniclastic Sediments—clasts of gray dacite and minor varicolored rhyolite. 955– 965' WR/+10F: 95-100% angular grains of dacite, rhyolite, and ash flow tuff up to 15 mm; <5% devitrified white pumice clasts. +35F: 95-100% angular to subangular volcaniclastic grains, mostly dacite with minor rhyolite; <5% devitrified pumice clasts; trace quartz grains.	Tpf	

DEPTH (ft bgs)	LITHOLOGY	LITHOLOGIC SYMBOL	NOTES
965-1025	Volcaniclastic Sediments—clasts of gray dacite and varicolored rhyolite. 965– 1025' WR/+10F: 95-100% angular grains of dacite, rhyolite, and ash flow tuff up to 25 mm; <5% devitrified white pumice clasts. +35F: 95-100% angular to subangular volcaniclastic grains, mostly dacite with minor rhyolite; <5% devitrified pumice clasts; trace quartz grains.	Tpf	
1025-1055	Volcaniclastic Sediments—clasts of gray dacite and varicolored rhyolite. 1025– 1055' WR/+10F: 95-100% angular grains of dacite, rhyolite, and ash flow tuff up to 25 mm; <5% devitrified white pumice clasts. +35F: 90-95% angular to subangular volcaniclastic grains, mostly dacite with minor rhyolite; 5% devitrified pumice clasts; <5% quartz grains.	Tpf	
1055-1150	Volcaniclastic Sediments—clasts of gray dacite and varicolored rhyolite. 1055– 1150' WR/+10F: 95-100% angular grains of dacite, rhyolite, and ash flow tuff up to 25 mm; <5% devitrified white pumice clasts. +35F: 95-100% angular to subangular volcaniclastic grains, mostly dacite with minor rhyolite; <5% devitrified pumice clasts; trace quartz grains.	Tpf	
1150-1165	Volcaniclastic Sediments—clasts of gray dacite and varicolored rhyolite. 1150– 1165' WR/+10F: 95-100% angular to subangular grains of dacite, rhyolite, and ash flow tuff up to 25 mm; <5% devitrified white pumice clasts. +35F: 95-100% angular to subangular volcaniclastic grains, mostly dacite with minor rhyolite; <5% devitrified pumice clasts; trace quartz grains.	Tpf	Note: clasts are more weathered than above.
1165-1175	Volcaniclastic Sediments—clasts of gray dacite and varicolored rhyolite. 1165– 1175' WR/+10F: 95-100% angular to subangular grains of dacite, rhyolite, and ash flow tuff up to 25 mm with abundant fines; <5% devitrified white pumice clasts. +35F: 95-100% angular to subangular volcaniclastic grains, mostly dacite with minor rhyolite; <5% devitrified pumice clasts; trace quartz grains.	Tpf	
1175-1235	Volcaniclastic Sediments—clasts of gray dacite and varicolored rhyolite. 1175– 1235' WR/+10F: 95-100% angular to subangular grains of dacite, rhyolite, and ash flow tuff up to 25 mm; <5% devitrified white pumice clasts. +35F: 95-100% angular to subangular volcaniclastic grains, mostly dacite with minor rhyolite; <5% devitrified pumice clasts; trace quartz grains.	Tpf	

DEPTH (ft bgs)	LITHOLOGY	LITHOLOGIC SYMBOL	NOTES
1235-1285	Volcaniclastic Sediments—clasts of gray dacite and varicolored rhyolite. 1235–1285' WR/+10F: 95-100% angular grains of dacite, rhyolite, and ash flow tuff up to 20 mm with abundant fines; <5% devitrified white pumice clasts. +35F: 80-90% angular to subangular volcaniclastic grains, mostly dacite with minor rhyolite; 5-10% quartz grains; 5-10% devitrified pumice clasts.	Tpf	Note: increase in quartz and fine to very fine sand size grains in +35F sieve fraction.
1285-1350	Volcaniclastic Sediments—clasts of gray dacite and varicolored rhyolite. 1285– 1350' WR/+10F: 95-100% angular to subangular grains of dacite, rhyolite, and ash flow tuff up to 15 mm; <5% devitrified white pumice clasts. +35F: 95-100% angular to subangular volcaniclastic grains, mostly dacite with minor rhyolite; <5% devitrified pumice clasts; trace quartz grains.	Tpf	
1350-1397	Volcaniclastic Sediments—clasts of gray dacite and varicolored rhyolite. 1350–1397' WR/+10F: 95-100% angular grains of dacite, rhyolite, and ash flow tuff up to 20 mm with abundant fines; <5% devitrified white pumice clasts. +35F: 95-100% angular to subangular volcaniclastic grains, mostly dacite with minor rhyolite; <5% devitrified pumice clasts; trace quartz grains.	Tpf	Note: drilling at R-47 was concluded at a total depth of 1397 ft bgs.

Borehole Lithologic Log (continued)

ABBREVIATIONS

5YR 8/4 (example) = 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

B-1.0 SCREENING GROUNDWATER ANALYSES AT R-47

R-47 is a regional aquifer monitoring well with one well screen from 1322 ft to1343.3 ft below ground surface (bgs) in Puye Formation volcaniclastic sediments. This appendix presents screening analytical results for samples collected during well development and aquifer testing at R-47.

Laboratory Analyses

Six groundwater samples were collected during development and two groundwater samples were collected during aquifer testing. Los Alamos National Laboratory's (LANL's or the Laboratory's) Earth and Environmental Sciences 14 group analyzed the well development samples for total organic carbon (TOC) and the aquifer test samples for RDX (hexahydro-1,3,5-trinitro-1,3,5-triazine). Table B-1.0-1 lists the samples submitted for TOC analyses from R-47.

Field Analyses

Additionally, groundwater samples were collected from a flow-through cell at regular intervals during well development and aquifer testing and 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 during well development and aquifer testing.

B-2.1 Total Organic Carbon

TOC concentrations were between 0.8 mgC/L and 0.9 mgC/L in six groundwater samples collected during well development at well R-47 and analyzed by U.S. Environmental Protection Agency (EPA) Method SW-846:9060 (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.

B-2.2 Field Parameters

Field parameters measured during well development and aquifer testing are summarized in Table B-2.2-1. Well development was initially conducted for 5 d. Aquifer testing was then conducted for 3 d. These activities were conducted consecutively, and the field parameters are summarized below.

During well development and aquifer testing, pH varied from 7.17 to 8.79 and temperature ranged from 7.85°C to 18.80°C. DO concentrations varied from 2.50 mg/L to 12.84 mg/L. Specific conductance ranged from 22 to 164 μS/cm, and turbidity values varied from 6.5 nephelometric turbidity units (NTU) to 1320.6 NTU. Corrected oxidation-reduction potential (Eh) values, determined from field ORP measurements, varied from 266.9 mV to 371.9 mV. Three temperature-dependent correction factors were used to calculate Eh values from field ORP measurements: 208.9, 203.9, and 198.5 mV at 15°C, 20°C, and 25°C, respectively. Figure B-2.2-1 shows the field parameters measured over the course of well development and aquifer testing.

The final parameters measured at the end of the aquifer testing period were pH of 7.88, temperature of 12.98°C, DO of 7.13 mg/L, specific conductance of 161.0 μS/cm, and turbidity of 8.4 NTU.

B-3.0 SUMMARY OF SCREENING ANALYTICAL RESULTS

TOC concentrations were below the target level of 2.0 mgC/L and turbidity was 8.4 NTU at the end of aquifer testing. Well R-47 will be sampled quarterly for 1 yr, and data collected will be assessed and incorporated into the Interim Facility-Wide Groundwater Monitoring Plan. Data from ongoing sampling at R-47 will be analyzed and presented in the appropriate Laboratory periodic monitoring reports.

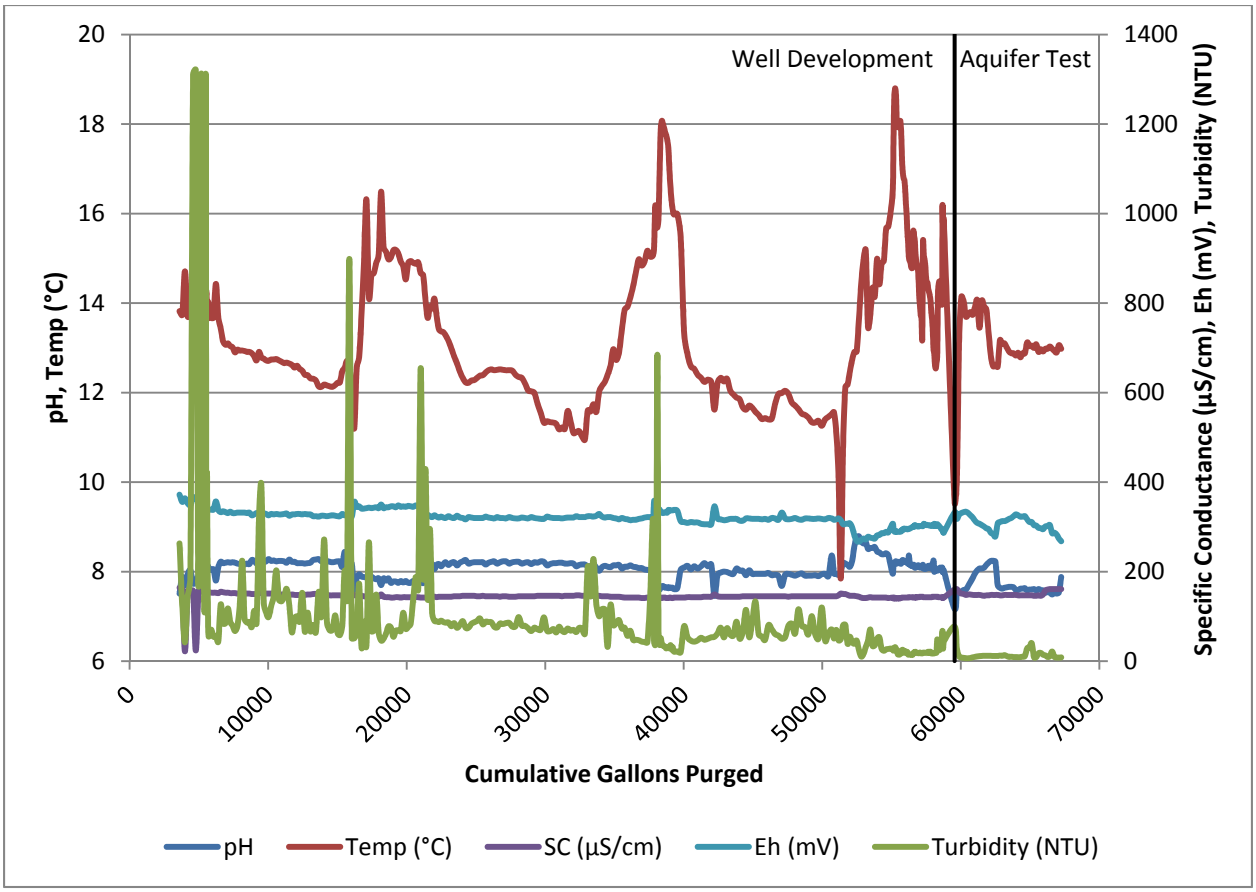


Figure B-2.2-1 R-47 Field parameters versus volume purged since start of well development

Table B-1.0-1
Summary of Groundwater Screening Samples Collected during Well Development and Aquifer Testing at Well R-64

Location ID	Sample ID	Date Collected	Collection Depth (ft bgs)	Sample Type	Analysis
Well Development					
R-47	CACV-14-85683	10/05/14	1339.32	Groundwater, Pumped	TOC
R-47	CACV-14-85684	10/06/14	1339.32	Groundwater, Pumped	TOC
R-47	CACV-14-85685	10/06/14	1321	Groundwater, Pumped	TOC
R-47	CACV-14-85686	10/07/14	1339.32	Groundwater, Pumped	TOC
R-47	CACV-14-85687	10/07/14	1321	Groundwater, Pumped	TOC
R-47	CACV-14-85688	10/08/14	1321	Groundwater, Pumped	TOC
Aquifer Testing					
R-47	CACV-14-85675	10/13/14	1326.7	Groundwater, Pumped	RDX
R-47	CACV-14-85676	10/14/14	1326.7	Groundwater, Pumped	RDX

Table B-2.1-1
TOC Results

Sample ID	EPA Method	TOC Concentration (mgC/L)
CACV-14-85683	SW-846:9060	0.8
CACV-14-85684	SW-846:9060	0.8
CACV-14-85685	SW-846:9060	0.9
CACV-14-85686	SW-846:9060	0.8
CACV-14-85687	SW-846:9060	0.9
CACV-14-85688	SW-846:9060	0.8

Table B-2.2-1
Purge Volumes and Field Parameters during Well Development and Aquifer Testing at R-64

Date	pH	Temp (°C)	DO (mg/L)	ORP (mV)	Eh (mV)	Specific Conductivity (µS/cm)	Turbidity (NTU)	Purge Volume between Samples (gal.)	Cumulative Purge Volume (gal.)
Well Development									
10/01/14	n/r*; bailing							20	20
10/02/14	n/r; bailing							75	95
10/03/14	n/r; bailing							60	155
10/04/14	n/r; pumping in sump							3248.7	3403.7
10/04/14	7.51	13.82	10.37	163	371.9	164	263	196	3599.7
	7.88	13.74	10.65	147	355.9	161	125.7	196	3795.7
	7.69	14.71	8.02	155	363.9	22	42.2	196	3991.7
	7.94	13.7	11.03	144	352.9	157	146.7	196	4187.7
	8.03	13.71	10.89	140	348.9	157	189.1	196	4383.7
	7.74	13.96	10.53	157	365.9	157	1311.1	196	4579.7
	7.76	14.88	8.48	154	362.9	24	1320.6	196	4775.7
	7.91	14.07	9.37	148	356.9	157	166.4	197	4972.7
	7.88	14.57	10.72	150	358.9	156	1313.1	197	5169.7
	7.86	14.36	9.55	148	356.9	155	188.7	197	5366.7
	8.02	15.57	8.75	136	344.9	158	109	42	5408.7
	8.09	14.47	9.65	133	341.9	154	266.4	42	5450.7
	8.09	14.07	9.16	132	340.9	153	1312.2	42.5	5493.2
	8.06	14.27	9.6	133	341.9	152	142.2	43	5536.2
	8.09	14.01	12.25	131	339.9	152	420.8	43	5579.2
	8.13	13.65	10.69	129	337.9	152	226.6	43	5622.2
	8.12	14.02	9.83	129	337.9	153	76.6	43	5665.2
	8.08	13.94	10.89	129	337.9	154	54.7	43	5708.2
	8.04	13.67	12.84	130	338.9	153	70.4	172.7	5880.9
	8.05	13.68	11.47	130	338.9	153	54.8	172.7	6053.6
	7.8	14.43	9.64	148	356.9	153	56.1	172.7	6226.3
	8.1	13.69	9.04	129	337.9	152	43.7	172.7	6399
	8.22	13.44	8.65	124	332.9	155	126.6	172.7	6571.7
	8.19	13.15	8.74	126	334.9	154	84.8	172.7	6744.4
	8.2	13.07	8.9	124	332.9	153	84.8	172.7	6917.1
	8.21	13.1	8.92	122	330.9	153	117.8	172.7	7089.8
	8.2	13.04	9	125	333.9	152	88.4	172.7	7262.5
	8.21	13.01	9.09	122	330.9	152	79	172.7	7435.2
	8.2	12.9	9.08	122	330.9	152	67.3	172.7	7607.9
	8.18	12.96	9.24	123	331.9	151	78.3	172.7	7780.6

Table B-2.2-1 (continued)

Date	pH	Temp (°C)	DO (mg/L)	ORP (mV)	Eh (mV)	Specific Conductivity (µS/cm)	Turbidity (NTU)	Purge Volume between Samples (gal.)	Cumulative Purge Volume (gal.)
Well Development									
10/04/14	8.17	12.94	9.04	123	331.9	151	128.2	172.7	7953.3
	8.15	12.94	9.15	123	331.9	151	224.2	172.7	8126
	8.16	12.93	9.01	123	331.9	151	94.3	172.7	8298.7
	8.18	12.91	9.12	122	330.9	151	86.3	172.7	8471.4
	8.17	12.91	9.16	123	331.9	151	87.2	172.7	8644.1
	8.26	12.88	9.08	117	325.9	150	76.3	172.7	8816.8
	8.24	12.81	9	119	327.9	150	112.5	172.7	8989.5
	8.18	12.72	9.05	122	330.9	150	85.6	172.7	9162.2
	8.18	12.91	10.22	122	330.9	152	314.9	172.8	9335
	8.29	12.79	9.11	117	325.9	152	393.3	172.8	9507.8
	8.22	12.76	9.13	121	329.9	151	130.6	172.8	9680.6
	8.23	12.72	9.03	120	328.9	151	108.6	172.8	9853.4
	8.28	12.71	9.11	117	325.9	151	98.5	172.8	10026.2
	8.24	12.74	9.17	120	328.9	151	123.1	187.1	10213.3
10/05/14	8.25	12.74	9.07	119	327.9	150	145.6	187.1	10400.4
	8.23	12.75	9.04	120	328.9	150	202.8	187.1	10587.5
	8.24	12.72	9.09	119	327.9	150	137.7	187.1	10774.6
	8.24	12.69	9.14	119	327.9	149	133.7	187.1	10961.7
	8.23	12.66	9.07	120	328.9	149	144.3	187.1	11148.8
	8.2	12.67	9.11	121	329.9	149	161.4	187.1	11335.9
	8.27	12.65	9.07	116	324.9	148	125.5	187.1	11523
	8.22	12.62	9.11	119	327.9	149	64.6	187.2	11710.2
	8.22	12.56	9.17	119	327.9	148	95.9	187.2	11897.4
	8.19	12.6	9.1	120	328.9	148	100.1	187.2	12084.6
	8.19	12.53	9.12	120	328.9	148	88.9	187.2	12271.8
	8.19	12.49	9.12	119	327.9	148	152.5	187.2	12459
	8.18	12.4	9.16	120	328.9	148	65.9	187.2	12646.2
	8.19	12.39	9.17	119	327.9	149	108.5	199.4	12845.6
	8.2	12.32	9.14	119	327.9	149	66.7	199.4	13045
	8.26	12.31	9.18	115	323.9	150	80.9	199.4	13244.4
	8.27	12.27	9.16	115	323.9	150	64.9	199.4	13443.8
	8.28	12.14	9.24	114	322.9	148	154.9	199.4	13643.2
	8.23	12.13	9.19	116	324.9	148	100.9	199.5	13842.7
	8.24	12.18	9.17	116	324.9	148	272	199.5	14042.2
	8.24	12.16	9.2	115	323.9	148	87.4	199.5	14241.7
	8.22	12.14	9.23	116	324.9	147	69	199.5	14441.2

Table B-2.2-1 (continued)

Date	pH	Temp (°C)	DO (mg/L)	ORP (mV)	Eh (mV)	Specific Conductivity (µS/cm)	Turbidity (NTU)	Purge Volume between Samples (gal.)	Cumulative Purge Volume (gal.)
Well Development									
10/05/14	8.21	12.13	9.24	117	325.9	147	70.1	199.5	14640.7
	8.22	12.17	9.26	116	324.9	147	102.3	199.5	14840.2
	8.23	12.22	9.22	115	323.9	147	62.6	170	15010.2
	8.22	12.23	9.3	115	323.9	147	58.3	170	15180.2
	8.11	12.48	9.66	120	328.9	146	79.3	170	15350.2
	8.44	12.55	9.61	117	325.9	146	202.5	170	15520.2
	8.13	12.71	10.46	119	327.9	146	140	170	15690.2
	8.16	12.56	10.7	119	327.9	146	898.6	170	15860.2
	8.18	12.04	10.3	114	322.9	147	51.5	176.4	16036.6
	7.6	11.2	10.61	147	355.9	148	50.9	176.4	16213
	7.85	12.54	9.8	136	344.9	146	62.7	176.4	16389.4
	7.94	12.79	9.08	137	345.9	148	173	176.4	16565.8
	7.89	13.76	10.35	132	340.9	146	30.2	176.4	16742.2
	7.88	14.94	8.86	132	340.9	145	88.2	176.4	16918.6
	7.87	16.31	8.65	133	341.9	144	36.2	176.4	17095
	7.88	14.14	10.24	134	342.9	146	265.5	176.4	17271.4
	7.89	14.62	9.05	133	341.9	145	67.2	176.4	17447.8
	7.85	14.67	8.74	134	342.9	145	68.2	176.4	17624.2
	7.83	14.9	8.55	135	343.9	144	148.8	176.4	17800.6
	7.85	15.08	8.54	133	341.9	144	63.2	176.4	17977
	7.7	16.49	8.14	141	349.9	149	46.2	176.4	18153.4
	7.85	15.26	8.73	133	341.9	144	50	176.4	18329.8
	7.8	15.15	8.78	135	343.9	143	61.5	176.4	18506.2
	7.85	14.98	8.89	135	343.9	143	77.6	176.5	18682.7
	7.75	15.02	8.71	137	345.9	142	75.3	176.5	18859.2
	7.78	15.18	9.19	137	345.9	142	54.5	176.5	19035.7
	7.78	15.19	8.95	135	343.9	143	67.7	176.5	19212.2
	7.75	15.11	9.09	139	347.9	143	68.7	180	19392.2
	7.79	14.93	8.76	136	344.9	142	67.5	180	19572.2
	7.76	14.82	8.99	137	345.9	143	108.1	180	19752.2
	7.79	14.53	9.59	136	344.9	143	72.5	180	19932.2
	7.75	14.9	8.83	138	346.9	143	76.8	180	20112.2
	7.75	14.94	8.76	137	345.9	143	84.1	180	20292.2
	7.79	14.9	8.73	136	344.9	143	137.8	180	20472.2
	7.74	14.88	8.84	139	347.9	143	187.9	180	20652.2
	7.77	14.91	9.17	137	345.9	143	160.6	180	20832.2

Table B-2.2-1 (continued)

Date	pH	Temp (°C)	DO (mg/L)	ORP (mV)	Eh (mV)	Specific Conductivity (µS/cm)	Turbidity (NTU)	Purge Volume between Samples (gal.)	Cumulative Purge Volume (gal.)
Well Development									
10/05/14	7.78	14.67	9	136	344.9	142	654.9	180	21012.2
	7.75	14.62	9.16	138	346.9	142	185.3	180	21192.2
	8.11	14.08	10.49	116	324.9	142	429.2	161.4	21353.6
	8.08	13.67	9.48	118	326.9	141	138.6	161.4	21515
	8.15	13.92	9.11	115	323.9	143	295.4	161.4	21676.4
	8.17	13.88	9.96	113	321.9	143	107.5	161.4	21837.8
	8.06	14.1	9.67	117	325.9	144	90.2	161.4	21999.2
	8.15	13.71	10.09	114	322.9	143	89.1	161.4	22160.6
	8.17	13.42	10.15	112	320.9	144	87.4	161.4	22322
	8.12	13.37	10.2	114	322.9	144	90.4	161.4	22483.4
	8.17	13.35	10.16	112	320.9	144	87.7	161.4	22644.8
	8.21	13.28	9.95	111	319.9	144	85.9	161.4	22806.2
	8.15	13.16	10.31	115	323.9	144	86.5	206.8	23013
	8.2	12.99	10.52	112	320.9	144	78.2	206.8	23219.8
	8.21	12.81	10.36	111	319.9	145	85	206.8	23426.6
	8.14	12.65	10.55	116	324.9	145	74.6	206.8	23633.4
	8.2	12.47	10.44	112	320.9	145	81	206.8	23840.2
	8.23	12.33	10.71	111	319.9	146	89.4	206.8	24047
	8.26	12.23	10.13	108	316.9	146	74.7	206.8	24253.8
	8.18	12.22	10.12	113	321.9	146	74.7	206.8	24460.6
	8.2	12.27	10.37	112	320.9	146	83.3	206.8	24667.4
	8.21	12.28	10.06	111	319.9	146	86.9	206.8	24874.2
	8.21	12.33	10.46	111	319.9	145	89.9	206.8	25081
	8.21	12.38	10.26	111	319.9	145	95.5	206.8	25287.8
	8.21	12.39	10.59	111	319.9	146	82.2	206.8	25494.6
	8.16	12.45	10.76	114	322.9	145	88.2	206.8	25701.4
	8.2	12.5	10.5	112	320.9	145	87.3	206.8	25908.2
	8.22	12.52	10.38	111	319.9	145	86.7	206.9	26115.1
	8.23	12.5	10.09	110	318.9	145	76.8	206.9	26322
	8.18	12.51	10.55	113	321.9	145	75.3	206.9	26528.9
	8.21	12.52	10.48	111	319.9	144	84.1	206.9	26735.8
	8.23	12.51	10.63	111	319.9	145	82.9	206.9	26942.7
	8.23	12.5	10.53	110	318.9	145	85.1	227.8	27170.5
	8.18	12.5	10.65	113	321.9	144	85.6	227.8	27398.3
	8.21	12.49	10.7	111	319.9	144	77.2	227.8	27626.1
	8.22	12.4	10.33	110	318.9	144	78	227.8	27853.9

Table B-2.2-1 (continued)

Date	pH	Temp (°C)	DO (mg/L)	ORP (mV)	Eh (mV)	Specific Conductivity (µS/cm)	Turbidity (NTU)	Purge Volume between Samples (gal.)	Cumulative Purge Volume (gal.)
Well Development									
10/06/14	8.22	12.35	11.03	110	318.9	145	98.4	227.8	28081.7
	8.18	12.33	10.42	112	320.9	145	79.7	227.8	28309.5
	8.2	12.21	10.5	111	319.9	145	79	227.8	28537.3
	8.21	12.05	10.24	110	318.9	145	73.5	227.8	28765.1
	8.17	12.03	10.75	113	321.9	145	67.3	227.8	28992.9
	8.21	11.99	10.97	111	319.9	145	74.8	227.8	29220.7
	8.2	11.75	10.43	110	318.9	146	98.4	227.8	29448.5
	8.23	11.55	10.42	109	317.9	146	79.7	227.8	29676.3
	8.22	11.33	10.38	109	317.9	146	97.8	227.8	29904.1
	8.14	11.36	11	114	322.9	146	68	227.7	30131.8
	8.17	11.34	10.47	112	320.9	146	67.3	227.7	30359.5
	8.19	11.33	10.83	111	319.9	146	71.7	227.7	30587.2
	8.19	11.3	10.93	111	319.9	146	64.3	207	30794.2
	8.2	11.18	10.9	111	319.9	146	76.9	207	31001.2
	8.2	11.22	10.16	110	318.9	145	68	207	31208.2
	8.18	11.19	10.57	111	319.9	146	65.2	207	31415.2
	8.18	11.59	11.35	112	320.9	146	72.9	207	31622.2
	8.19	11.36	11.28	112	320.9	146	68.2	207	31829.2
	8.18	11.1	10.68	112	320.9	146	69.8	207	32036.2
	8.12	11.12	10.51	115	323.9	147	65.1	207	32243.2
	8.15	11.14	10.84	113	321.9	147	74.3	207	32450.2
	8.16	11.02	10.67	113	321.9	146	72.2	207	32657.2
	8.16	10.95	10.98	113	321.9	146	61.4	207	32864.2
	8.12	11.6	9.43	115	323.9	145	211.1	207	33071.2
	8.12	11.58	9.41	115	323.9	146	144.4	207	33278.2
	8.17	11.74	9.32	114	322.9	146	228.4	204.8	33483
	8.09	11.57	9.26	116	324.9	146	128	204.8	33687.8
	8.02	12.02	10.11	120	328.9	146	100.4	204.8	33892.6
	8.1	12.15	10.47	114	322.9	145	116.3	204.8	34097.4
	8.13	12.24	9.87	112	320.9	145	115.1	204.8	34302.2
	8.11	12.4	9.71	113	321.9	145	31.8	204.8	34507
	8.1	12.6	9.43	113	321.9	144	125.9	204.8	34711.8
	8.14	12.97	9.31	111	319.9	144	80.6	204.8	34916.6
	8.14	12.73	9.6	110	318.9	144	85	204.8	35121.4
	8.15	12.89	9.26	108	316.9	144	91.7	204.8	35326.2
	8.07	13.4	9.25	111	319.9	143	73.1	204.8	35531

Table B-2.2-1 (continued)

Date	pH	Temp (°C)	DO (mg/L)	ORP (mV)	Eh (mV)	Specific Conductivity (µS/cm)	Turbidity (NTU)	Purge Volume between Samples (gal.)	Cumulative Purge Volume (gal.)
Well Development									
10/06/14	8.11	13.85	9.09	109	317.9	142	74.5	204.8	35735.8
	8.11	13.92	9.09	108	316.9	142	56.5	204.8	35940.6
	8.14	14.13	9.08	106	314.9	142	67.9	204.8	36145.4
	8.11	14.38	9.84	107	315.9	142	47.5	204.8	36350.2
	8.1	14.7	10.39	107	315.9	142	47.8	204.8	36555
	8.08	14.98	10.1	109	317.9	142	46.7	204.8	36759.8
	8.08	14.84	10.67	110	318.9	141	43.6	204.8	36964.6
	8.05	14.93	9.46	112	320.9	141	42.9	204.8	37169.4
	8.04	15.17	9.41	113	321.9	142	42.2	204.8	37374.2
	8.03	15.04	8.05	113	321.9	141	145	204.8	37579
	8.04	15.07	8.46	111	319.9	141	316.6	204.8	37783.8
	7.51	15.27	8.2	149	357.9	143	43	79.1	37862.9
	7.68	16.17	8.69	136	344.9	141	35.9	79.1	37942
	7.59	15.85	8.35	139	347.9	141	210.3	79.1	38021.1
	7.59	15.69	8.08	133	341.9	141	683.6	79.1	38100.2
	7.63	15.91	7.91	129	337.9	141	66.3	79.2	38179.4
	7.6	16.93	7.91	130	338.9	141	36.2	79.2	38258.6
	7.63	17.88	7.74	130	333.9	142	51.4	79.2	38337.8
	7.67	18.07	7.71	128	331.9	141	39.3	79.2	38417
	7.68	18.01	7.68	127	330.9	142	34.6	79.2	38496.2
	7.66	17.92	7.65	128	331.9	142	34.3	79.2	38575.4
	7.64	17.82	7.51	129	332.9	142	31.5	79.2	38654.6
	7.65	17.75	7.58	128	331.9	141	28.6	79.2	38733.8
	7.65	17.64	7.55	128	331.9	141	31.7	79.2	38813
	7.63	17.46	7.58	129	337.9	141	28.9	79.2	38892.2
	7.65	16.95	7.61	127	335.9	142	30.8	79.2	38971.4
	7.64	16.56	7.66	128	336.9	142	35.7	79.2	39050.6
	7.64	16.26	7.68	128	336.9	141	25.8	79.2	39129.8
	7.64	16.08	7.7	128	336.9	141	31.3	79.2	39209
	7.61	15.98	8.47	129	337.9	142	21.5	79.2	39288.2
	7.63	15.99	8.4	127	335.9	142	21.6	245.2	39533.4
	8.04	15.47	7.98	104	312.9	142	20.1	245.2	39778.6
	8.09	13.35	8.22	102	310.9	142	77.9	245.2	40023.8
	8.13	12.86	8.11	100	308.9	143	53.8	245.3	40269.1
	8.05	12.59	8.41	102	310.9	143	45.8	245.3	40514.4
	8.12	12.53	8.91	101	309.9	143	43.6	245.3	40759.7

Table B-2.2-1 (continued)

Date	pH	Temp (°C)	DO (mg/L)	ORP (mV)	Eh (mV)	Specific Conductivity (µS/cm)	Turbidity (NTU)	Purge Volume between Samples (gal.)	Cumulative Purge Volume (gal.)
Well Development									
10/06/14	8.07	12.4	8.86	101	309.9	143	46.5	245.3	41005
	8.12	12.33	8.91	98	306.9	143	52.2	245.3	41250.3
	8.19	12.24	9.06	97	305.9	144	47.9	245.3	41495.6
	8.12	12.29	9.3	97	305.9	144	50.2	245.3	41740.9
	8.16	12.24	9.01	97	305.9	144	53.3	245.3	41986.2
	7.46	11.62	9.43	137	345.9	149	54.4	228.1	42214.3
	7.93	12.22	9.61	110	318.9	145	62.1	228.1	42442.4
	7.98	12.33	8.93	108	316.9	144	74.7	228.1	42670.5
	8	12.25	8.74	106	314.9	144	53.1	228.1	42898.6
	7.99	12.31	9.26	107	315.9	144	73.9	228.1	43126.7
	7.96	12.05	8.89	109	317.9	144	59.2	228.1	43354.8
	7.95	11.96	8.85	109	317.9	144	57.3	228.1	43582.9
	8.07	11.89	9.19	109	317.9	144	88.1	228.1	43811
	8.02	11.85	8.75	105	313.9	144	50.2	228.1	44039.1
	8.02	11.67	9.06	105	313.9	145	65.6	228.1	44267.2
	7.92	11.62	9.07	110	318.9	145	114.5	228.1	44495.3
	8.03	11.71	9.15	110	318.9	145	53.6	228.1	44723.4
10/07/14	7.95	11.66	9.34	109	317.9	145	90.3	228.2	44951.6
	7.95	11.57	8.98	109	317.9	145	133.2	228.2	45179.8
	7.95	11.5	8.78	109	317.9	145	60.2	228.2	45408
	7.95	11.41	8.87	108	316.9	145	55.4	228.2	45636.2
	7.95	11.43	9.18	109	317.9	145	47.8	240.4	45876.6
	7.97	11.4	9.33	107	315.9	145	80.4	240.4	46117
	7.92	11.42	9.05	111	319.9	145	71.1	240.4	46357.4
	7.93	11.75	8.8	110	318.9	145	60.4	240.4	46597.8
	7.9	11.97	9.38	107	315.9	145	57	240.4	46838.2
	7.68	11.99	10.11	123	331.9	145	50.2	240.4	47078.6
	7.93	12.04	8.69	110	318.9	145	53.4	240.4	47319
	7.95	11.97	8.59	108	316.9	144	79.4	240.4	47559.4
	7.93	11.78	8.54	109	317.9	145	83.5	240.4	47799.8
	7.91	11.71	8.64	111	319.9	145	61.7	240.4	48040.2
	7.94	11.63	9.55	108	316.9	145	115.8	240.4	48280.6
	7.96	11.53	9.58	107	315.9	145	79.2	240.4	48521
	7.91	11.5	8.91	110	318.9	145	76	240.4	48761.4
	7.91	11.44	9.48	110	318.9	145	59.8	240.4	49001.8
	7.91	11.34	9.74	109	317.9	145	100.5	240.4	49242.2

Table B-2.2-1 (continued)

Date	pH	Temp (°C)	DO (mg/L)	ORP (mV)	Eh (mV)	Specific Conductivity (µS/cm)	Turbidity (NTU)	Purge Volume between Samples (gal.)	Cumulative Purge Volume (gal.)
Well Development									
10/07/14	7.92	11.33	9.59	109	317.9	145	60.7	240.5	49482.7
	7.9	11.37	9.59	110	318.9	145	50.4	240.5	49723.2
	7.94	11.26	9.38	109	317.9	145	120.1	240.5	49963.7
	7.95	11.4	9.35	108	316.9	145	46.1	240.5	50204.2
	7.9	11.46	9.1	111	319.9	145	62.3	240.5	50444.7
	8.36	11.52	9.81	110	318.9	145	70.6	240.5	50685.2
	7.96	11.56	9.86	107	315.9	145	50.6	163.6	50848.8
	7.95	11.1	8.74	108	316.9	145	69.9	163.6	51012.4
	7.93	10.11	9.2	110	318.9	147	46.6	163.6	51176
	8.01	7.85	9.7	106	314.9	151	49.4	163.6	51339.6
	8.19	10.78	8.71	97	305.9	150	80	163.6	51503.2
	8.18	12.12	8.52	98	306.9	150	80.8	163.6	51666.8
	8.15	12.18	9.79	98	306.9	148	38.9	163.6	51830.4
	8.11	12.47	9.75	99	307.9	146	54.5	163.6	51994
	8.24	12.73	9.93	90	298.9	146	42.7	163.6	52157.6
	8.57	12.91	9.87	72	280.9	146	39	163.6	52321.2
	8.76	12.92	8.54	60	268.9	145	45.9	163.6	52484.8
	8.79	13.64	8.67	58	266.9	144	24.4	163.6	52648.4
	8.68	14.43	8.21	62	270.9	142	10.3	163.6	52812
	8.63	14.96	8.13	65	273.9	141	16.1	163.6	52975.6
	8.66	15.18	8.03	63	271.9	141	31.5	163.6	53139.2
	8.51	13.47	8.54	69	277.9	142	46.1	163.7	53302.9
	8.53	13.73	8.74	67	275.9	143	70.7	163.7	53466.6
	8.53	14.34	9.53	66	274.9	142	34.2	163.7	53630.3
	8.55	14.15	8.25	65	273.9	142	35.4	163.7	53794
	8.45	14.99	8.69	72	280.9	142	50.1	163.7	53957.7
	8.43	14.42	8.33	73	281.9	142	53.1	163.7	54121.4
	8.39	14.89	8.64	77	285.9	142	27.5	163.7	54285.1
	8.39	14.95	7.96	77	285.9	142	23.2	163.7	54448.8
	8.41	15.67	8.21	80	288.9	142	26.5	163.7	54612.5
	8.36	15.72	8.38	79	287.9	141	27.3	163.7	54776.2
	n/r; pumping without measurements							236	55012.2
	7.96	16.45	7.63	98	306.9	142	28	62.6	55074.8
	8.12	17.49	7.62	89	297.9	140	23.4	62.6	55137.4
	8.18	18.62	7.3	86	289.9	142	28.7	62.6	55200
	8.22	18.8	7.26	85	288.9	140	31.3	62.6	55262.6

Table B-2.2-1 (continued)

Date	pH	Temp (°C)	DO (mg/L)	ORP (mV)	Eh (mV)	Specific Conductivity (µS/cm)	Turbidity (NTU)	Purge Volume between Samples (gal.)	Cumulative Purge Volume (gal.)
Well Development									
10/07/14	8.23	18.64	7.25	87	290.9	141	27.4	62.6	55325.2
	8.18	17.98	7.38	85	288.9	140	25.2	62.6	55387.8
	8.22	17.93	7.62	85	288.9	140	15.5	62.6	55450.4
	8.2	18	7.45	85	288.9	141	14.6	62.6	55513
	8.19	18.06	7.35	85	288.9	140	14.7	62.6	55575.6
	8.18	18.07	7.29	86	289.9	141	16.2	62.6	55638.2
	8.18	17.79	7.27	86	289.9	141	19.2	62.6	55700.8
	8.25	17.16	7.25	85	293.9	142	24.9	62.7	55763.5
	8.26	16.89	7.34	84	292.9	142	25	62.7	55826.2
	8.22	16.78	7.33	87	295.9	142	21.6	53	55879.2
	8.22	16.74	7.34	87	295.9	142	18.7	53	55932.2
	8.23	16.54	7.31	87	295.9	142	22.3	53	55985.2
	8.21	16.23	7.35	87	295.9	142	21.7	53	56038.2
	8.22	15.97	7.37	86	294.9	142	19.7	53	56091.2
	8.21	15.6	7.53	86	294.9	142	20.3	53	56144.2
	8.18	15.35	7.54	86	294.9	142	14.9	53	56197.2
	8.36	15.03	7.63	87	295.9	143	14.6	53	56250.2
	8.22	14.95	7.63	87	295.9	143	14.4	53	56303.2
	8.14	14.92	7.72	88	296.9	143	14.6	53	56356.2
	8.16	14.82	7.68	89	297.9	143	13.9	54	56410.2
	8.15	14.78	7.62	90	298.9	143	14.4	54	56464.2
	8.12	14.79	7.66	91	299.9	143	14	54	56518.2
	8.15	15.61	7.34	92	300.9	142	17.4	54	56572.2
	8.15	15.51	7.51	91	299.9	142	19.8	54	56626.2
	8.09	15.4	7.55	95	303.9	142	19.5	54	56680.2
	8.09	15.09	7.61	94	302.9	143	21	54	56734.2
	8.12	14.95	7.59	93	301.9	142	18.4	54	56788.2
	8.11	14.84	7.6	93	301.9	143	18.4	54	56842.2
	8.14	14.82	7.6	92	300.9	143	18.1	54	56896.2
	8.14	14.53	7.62	92	300.9	143	18	54	56950.2
	8.11	14.13	7.76	93	301.9	143	17.8	54	57004.2
	8.09	13.92	7.77	93	301.9	144	19.3	54	57058.2
	8.1	13.72	7.74	93	301.9	144	17.7	54	57112.2
	8.1	13.65	7.75	93	301.9	144	17.4	54	57166.2
	8.14	13.21	7.86	93	301.9	144	17.4	54	57220.2

Table B-2.2-1 (continued)

Date	pH	Temp (°C)	DO (mg/L)	ORP (mV)	Eh (mV)	Specific Conductivity (µS/cm)	Turbidity (NTU)	Purge Volume between Samples (gal.)	Cumulative Purge Volume (gal.)
Well Development									
10/08/14	8.15	15.38	7.37	93	301.9	143	18.9	54	57274.2
	8.07	15.08	7.4	98	306.9	143	19.1	54	57328.2
	8.06	14.98	7.4	96	304.9	143	19	54	57382.2
	8.08	14.85	7.42	96	304.9	143	18.5	54	57436.2
	8.07	14.59	7.53	96	304.9	143	18.7	54	57490.2
	8.07	14.45	7.48	95	303.9	143	18.6	54	57544.2
	8.09	14.45	7.46	95	303.9	143	18.6	54	57598.2
	8.13	14.32	7.54	95	303.9	143	21.1	54	57652.2
	8.1	14.25	7.51	95	303.9	143	19.5	54	57706.2
	8.08	14.17	7.54	94	302.9	143	19.6	54	57760.2
	8.14	14.06	7.6	94	302.9	143	21.2	54	57814.2
	8.11	13.82	7.54	93	301.9	143	17.4	54	57868.2
	8.06	13.65	7.57	94	302.9	143	17.7	54	57922.2
	8.07	13.4	7.58	94	302.9	144	17.4	54	57976.2
	8.25	12.97	7.65	94	302.9	144	17.8	54	58030.2
	8	12.87	7.71	98	306.9	144	17.4	54	58084.2
	8.08	12.62	7.66	93	301.9	144	18.6	54	58138.2
	8.07	12.54	7.66	94	302.9	144	19.1	54	58192.2
	8.05	12.66	7.65	94	302.9	144	19	54	58246.2
	8.02	12.83	7.71	97	305.9	144	48.3	54	58300.2
	8.05	14.24	7.27	96	304.9	143	47.4	54	58354.2
	8.06	14.43	7.17	94	302.9	143	27.2	54	58408.2
	8.07	14.48	7.09	92	300.9	143	24.6	54	58462.2
	8.09	14.23	7.09	90	298.9	143	30.2	54	58516.2
	8.06	14.14	7.04	87	295.9	143	45.8	54	58570.2
	8.08	14.49	6.99	87	295.9	143	44	22.1	58592.3
	8.08	14.28	7.15	87	295.9	143	37.8	22.1	58614.4
	8.07	14.33	7.02	86	294.9	143	37.1	22.1	58636.5
	8.09	14	7.09	84	292.9	143	44.8	22.1	58658.6
	7.99	16.16	6.52	84	292.9	141	67.6	22.1	58680.7
	8.05	15.85	6.75	82	290.9	142	29.5	22.1	58702.8
	8.03	15.65	6.8	79	287.9	142	28	22.1	58724.9
	8.02	15.85	6.8	79	287.9	142	37.6	22.1	58747
	8.03	15.89	6.64	78	286.9	142	43.8	22.1	58769.1

Table B-2.2-1 (continued)

Date	pH	Temp (°C)	DO (mg/L)	ORP (mV)	Eh (mV)	Specific Conductivity (µS/cm)	Turbidity (NTU)	Purge Volume between Samples (gal.)	Cumulative Purge Volume (gal.)
Aquifer Pump Test									
10/10/14	n/r, pumping, mini-tests							186.1	58955.2
10/11/14	n/r, pumping, mini-tests							432.8	59388.0
10/13/14 to 10/14/14	7.17	9.57	2.5	123	331.9	160	77.2	163.8	59551.8
	7.54	10.04	3.8	109	317.9	161	28.5	163.8	59715.6
	7.52	13.14	5.46	118	326.9	154	10.7	163.8	59879.4
	7.56	14.14	5.88	122	330.9	151	8.2	163.8	60043.2
	7.59	14.04	6.09	124	332.9	150	7.5	163.8	60207
	7.6	13.7	6.49	125	333.9	148	6.6	163.8	60370.8
	7.68	13.74	6.59	122	330.9	149	6.5	163.8	60534.6
	7.77	13.8	6.65	117	325.9	149	7.2	163.8	60698.4
	7.86	13.74	6.68	112	320.9	148	8.5	163.8	60862.2
	7.96	13.91	6.8	105	313.9	148	9.7	163.8	61026
	8.03	14.06	6.77	100	308.9	148	10.5	163.8	61189.8
	8.07	13.45	6.92	98	306.9	148	11.2	163.8	61353.6
	8.07	14.05	6.88	95	303.9	147	11.6	163.8	61517.4
	8.09	13.92	6.9	92	300.9	146	12	163.8	61681.2
	8.15	13.86	6.91	88	296.9	147	11.9	163.8	61845
	8.2	13.34	6.93	86	294.9	147	11.8	163.8	62008.8
	8.24	12.82	7.06	78	286.9	148	11.8	163.8	62172.6
	8.24	12.59	7.07	75	283.9	148	11.6	163.8	62336.4
	8.22	12.62	7.08	70	278.9	148	11.6	163.8	62500.2
	7.7	12.58	7.11	99	307.9	148	11.5	163.8	62664
	7.64	13.17	6.85	102	310.9	147	12.5	163.8	62827.8
	7.62	13.09	6.87	104	312.9	147	12	163.8	62991.6
	7.64	13.1	6.8	104	312.9	148	13.4	163.8	63155.4
	7.65	13.01	6.8	106	314.9	148	11.4	163.8	63319.2
	7.66	12.92	6.68	109	317.9	148	9.5	163.8	63483
	7.66	12.88	6.93	111	319.9	148	10	163.8	63646.8
	7.65	12.88	7.02	115	323.9	148	9.2	163.8	63810.6
	7.59	12.83	6.94	119	327.9	148	9.2	163.8	63974.4
	7.59	12.89	6.89	117	325.9	147	8.9	163.8	64138.2
	7.62	12.79	6.98	114	322.9	147	9.1	163.8	64302
	7.62	12.88	6.62	114	322.9	147	9.9	163.8	64465.8
	7.63	12.88	6.69	115	323.9	147	11.5	163.8	64629.6

Table B-2.2-1 (continued)

Date	pH	Temp (°C)	DO (mg/L)	ORP (mV)	Eh (mV)	Specific Conductivity (µS/cm)	Turbidity (NTU)	Purge Volume between Samples (gal.)	Cumulative Purge Volume (gal.)
Aquifer Pump Test									
10/13/14 to 10/14/14	7.58	13.12	6.89	108	316.9	147	28.8	163.8	64793.4
	7.6	13.04	6.93	102	310.9	147	30.7	163.8	64957.2
	7.6	13.05	6.99	102	310.9	147	40	163.8	65121
	7.61	13	6.91	95	303.9	146	8.8	163.8	65284.8
	7.58	13.08	6.87	94	302.9	146	9	163.8	65448.6
	7.61	12.91	6.87	89	297.9	147	17.6	163.8	65612.4
	7.59	12.97	6.93	88	296.9	146	18.4	163.8	65776.2
	7.58	12.92	6.94	86	294.9	149	14.4	163.8	65940
	7.53	12.98	6.96	92	300.9	158	12.8	163.8	66103.8
	7.55	12.98	6.89	93	301.9	160	9.4	163.8	66267.6
	7.53	13.03	6.89	95	303.9	161	11.2	163.8	66431.4
	7.49	12.98	6.8	77	285.9	161	21.5	163.8	66595.2
	7.53	12.93	6.91	78	286.9	161	9.6	163.8	66759
	7.51	12.9	6.76	74	282.9	161	8.2	163.8	66922.8
	7.54	13.06	7.23	65	273.9	161	8	163.8	67086.6
	7.88	12.98	7.13	59	267.9	161	8.4	163.8	67250.4

Note: Eh value correction factors: 15°C, 208.9; 20°C, 203.9; 25°C, 198.5.
*n/r = Not recorded.

Appendix C

Aquifer Testing Report

C-1.0 INTRODUCTION

This appendix describes the hydraulic analysis of pumping tests conducted from October 10 to 14, 2014, at R-47, a regional aquifer well located at Technical Area 14 (TA-14). The tests on R-47 were conducted to characterize the saturated materials and quantify the hydraulic properties of the screened interval. Testing consisted of brief trial pumping, background water-level data collection, and a 24-h constant-rate pumping test.

As in most of the R-well pumping tests conducted on the Pajarito Plateau, an inflatable packer system was installed in R-47 to eliminate casing storage effects on the test data. This setup was effective and produced good data.

Conceptual Hydrogeology

Well R-47 is completed within Puye deposits. The well screen is 21.3 ft long, extending from 1322.0 to 1343.3 ft below ground surface (bgs). The static water level measured on October 9, 2014, before testing commenced was 1304.50 ft bgs. The ground surface elevation at the well was surveyed at 7423.32 ft above mean sea level (amsl), making the estimated water level elevation 6118.82 ft amsl.

The proximity of the water table to the top of the well screen typically leads to the assumption of unconfined aquifer conditions. The pumping test data were consistent with leaky confined to unconfined conditions.

R-47 Testing

Well R-47 was tested from October 11 to 15, 2014. On October 10, the pump was installed and operated long enough to fill the drop pipe and adjust the control valve to establish a suitable discharge rate. Testing began with brief trial pumping on October 11.

Trial testing of R-47 began at 8:00 a.m. on October 11 at a discharge rate of 5.5 gallons per minute (gpm) and continued for 30 min. Following 30 min of recovery, a second trial test was performed at 9:00 a.m. for 60 min at a discharge rate of 5.5 gpm. Following shutdown, recovery/background data were recorded for 46 h until the start of the 24-h pumping test.

Following background data collection, the 24-h pumping test was begun at 8:00 a.m. on October 13, at a discharge rate of 5.5 gpm. Pumping continued until 8:00 a.m. on October 14. Following shutdown, recovery data were recorded for 24 h until 8:00 a.m. on October 15. At 8:00 a.m., the inflatable packer was slowly depressurized and water-level data were recorded for an additional 30 min. Beginning at 8:30 a.m., the pump was pulled from the well.

C-2.0 BACKGROUND DATA

The background water-level data collected in conjunction with running the pumping tests allow the analyst to see what water-level fluctuations occur naturally in the aquifer and help to distinguish between water-level changes caused by conducting the pumping test and changes associated with other causes.

Background water-level fluctuations have several causes, among them barometric pressure changes, operation of other wells in the aquifer, Earth tides, and long-term trends related to weather patterns. The background data hydrographs from the monitored wells were compared with barometric pressure data from the area to determine if a correlation existed.

Previous pumping tests on the Plateau have demonstrated a barometric efficiency for most wells of between 90% and 100%. Barometric efficiency is defined as the ratio of water-level change divided by barometric pressure change, expressed as a percentage. In the initial pumping tests conducted on the early R-wells, downhole pressure was monitored using a vented pressure transducer. This equipment measures the difference between the total pressure applied to the transducer and the barometric pressure, this difference being the true height of water above the transducer.

Subsequent pumping tests, including at R-47, have utilized nonvented transducers. These devices record the total pressure on the transducer, that is, the sum of the water height plus the barometric pressure. This results in an attenuated "apparent" hydrograph in a barometrically efficient well. Take as an example a 90% barometrically efficient well. When monitored using a vented transducer, an increase in barometric pressure of 1 unit causes a decrease in recorded downhole pressure of 0.9 unit because the water level is forced downward 0.9 unit by the barometric pressure change. However, using a nonvented transducer, the total measured pressure increases by 0.1 unit (the combination of the barometric pressure increase and the water-level decrease). Thus, the resulting apparent hydrograph changes by a factor of 100 minus the barometric efficiency, and in the same direction as the barometric pressure change, rather than in the opposite direction.

Barometric pressure data were obtained from TA-54 tower site from the Environment, Health, and Safety–Operations Integration Office (ESH-OIO). The TA-54 measurement location is at an elevation of 6548 ft amsl, whereas the wellhead elevation is at 7423.32 ft amsl. The static water level in R-47 was 1304.50 ft below land surface, making the water table elevation 6118.82 ft amsl. Therefore, the measured barometric pressure data from TA-54 had to be adjusted to reflect the pressure at the elevation of the water table within R-47.

The following formula was used to adjust the measured barometric pressure data:

$$P_{WT} = P_{TA54} \exp\left[-\frac{g}{3.281R} \left(\frac{E_{R-47} - E_{TA54}}{T_{TA54}} + \frac{E_{WT} - E_{R-47}}{T_{WELL}} \right) \right] \qquad \textbf{Equation C-1}$$

Where, P_{WT} = barometric pressure at the water table inside R-47

P_{TA54} = barometric pressure measured at TA-54

g = acceleration of gravity, in m/s^2 (9.80665 m/s^2)

R = gas constant, in J/Kg/degree Kelvin (287.04 J/Kg/degree Kelvin)

E_{R-47} = land surface elevation at R-47 site, in feet (7423.32 ft)

E_{TA54} = elevation of barometric pressure measuring point at TA-54, in feet (6548 ft)

E_{WT} = elevation of the water level in R-47, in feet (6118.82 ft)

T_{TA54} = air temperature near TA-54, in degrees Kelvin (assigned a value of 49.4 degrees Fahrenheit, or 282.8 degrees Kelvin)

T_{WELL} = air column temperature inside R-47, in degrees Kelvin (assigned a value of 62.1 degrees Fahrenheit, or 289.9 degrees Kelvin)

This formula is an adaptation of an equation ESH-OIO provided. It can be derived from the ideal gas law and standard physics principles. An inherent assumption in the derivation of the equation is that the air temperature between TA-54 and the well is temporally and spatially constant and that the temperature of the air column in the well is similarly constant.

The corrected barometric pressure data reflecting pressure conditions at the water table were compared with the water-level hydrograph to discern the correlation between the two and determine whether water level corrections would be needed prior to data analysis.

C-3.0 IMPORTANCE OF EARLY DATA

When pumping or recovery first begins, the vertical extent of the cone of depression is limited to approximately the well screen length, the filter pack length, or the aquifer thickness in relatively thin permeable strata. For many pumping tests on the Plateau, the early pumping period is the only time that the effective height of the cone of depression is known with certainty because, soon after startup, the cone of depression expands vertically through permeable materials above and/or below the screened interval. Thus, the early data often offer the best opportunity to obtain hydraulic conductivity information because conductivity would equal the earliest-time transmissivity divided by the well screen length.

Unfortunately, in many pumping tests, casing-storage effects dominate the early-time data, potentially hindering the effort to determine the transmissivity of the screened interval. The duration of casing-storage effects can be estimated using the following equation (Schafer 1978, 098240).

$$t_c = \frac{0.6\left(D^2 - d^2\right)}{\frac{Q}{s}}$$

Equation C-2

Where, t_c = duration of casing storage effect, in minutes

D = inside diameter of well casing, in inches

d = outside diameter of column pipe, in inches

Q = discharge rate, in gallons per minute

s = drawdown observed in pumped well at time t_c, in feet

The calculated casing storage time is quite conservative. Often, the data show that significant effects of casing storage have dissipated after about half the computed time.

For wells screened across the water table or wells in which the filter pack can drain during pumping, there can be an additional storage contribution from the filter pack. The following equation provides an estimate of the storage duration accounting for both casing and filter pack storage.

$$t_c = \frac{0.6\left[\left(D^2 - d^2\right) + S_y\left(D_B^2 - D_C^2\right)\right]}{\frac{Q}{s}}$$

Equation C-3

Where, S_y = short term specific yield of filter media (typically 0.2)

D_B = diameter of borehole, in inches

D_C = outside diameter of well casing, in inches

This equation was derived from Equation C-2 on a proportional basis by increasing the computed time in direct proportion to the additional volume of water expected to drain from the filter pack. [To prove this, note that the left-hand term within the brackets is directly proportional to the annular area (and volume) between the casing and drop pipe while the right-hand term is proportional to the area (and volume)

between the borehole and the casing, corrected for the drainable porosity of the filter pack. Thus, the summed term within the brackets accounts for all of the volume (casing water and drained filter pack water) appropriately.]

In some instances, it is possible to eliminate casing storage effects by setting an inflatable packer above the tested screen interval before conducting the test. This was done successfully in the testing performed on R-47.

C-4.0 TIME-DRAWDOWN METHODS

Time-drawdown data can be analyzed using a variety of methods. Among them is the Theis method (1934-1935, 098241). The Theis equation describes drawdown around a well as follows:

$$s = \frac{114.6Q}{T} W(u)$$

Equation C-4

where,

$$W(u) = \int_u^\infty \frac{e^{-x}}{x} dx$$

Equation C-5

and

$$u = \frac{1.87 r^2 S}{Tt}$$

Equation C-6

and where, s = drawdown, in feet

Q = discharge rate, in gallons per minute

T = transmissivity, in gallons per day per foot

S = storage coefficient (dimensionless)

t = pumping time, in days

r = distance from center of pumpage, in feet

To use the Theis method of analysis, the time-drawdown data are plotted on log-log graph paper. Then, Theis curve matching is performed using the Theis type curve—a plot of the Theis well function $W(u)$ versus $1/u$. Curve matching is accomplished by overlaying the type curve on the data plot and, while keeping the coordinate axes of the two plots parallel, shifting the data plot to align with the type curve, effecting a match position. An arbitrary point, referred to as the match point, is selected from the overlapping parts of the plots. Match-point coordinates are recorded from the two graphs, yielding four values: $W(u)$: $1/u$, s, and t. Using these match-point values, transmissivity and storage coefficient are computed as follows:

$$T = \frac{114.6Q}{s} W(u)$$

Equation C-7

$$S = \frac{Tut}{2693r^2}$$

Equation C-8

where, T = transmissivity, in gallons per day per foot

S = storage coefficient

Q = discharge rate, in gallons per minute

$W(u)$ = match-point value

s = match-point value, in feet

u = match-point value

t = match-point value, in minutes

An alternative solution method applicable to time-drawdown data is the Cooper-Jacob method (1946, 098236), a simplification of the Theis equation that is mathematically equivalent to the Theis equation for most pumped well data. The Cooper-Jacob equation describes drawdown around a pumping well as follows:

$$s = \frac{264Q}{T} \log \frac{0.3Tt}{r^2 S}$$

Equation C-9

The Cooper-Jacob equation is a simplified approximation of the Theis equation and is valid whenever the u value is less than about 0.05. For small radius values (e.g., corresponding to borehole radii), u is less than 0.05 at very early pumping times and therefore is less than 0.05 for most or all measured drawdown values. Thus, for the pumped well, the Cooper-Jacob equation usually can be considered a valid approximation of the Theis equation. An exception occurs when the transmissivity of the aquifer is very low. In that case, some of the early pumped well drawdown data may not be well approximated by the Cooper-Jacob equation.

According to the Cooper-Jacob method, the time-drawdown data are plotted on a semilog graph, with time plotted on the logarithmic scale. Then a straight line of best fit is constructed through the data points and transmissivity is calculated using:

$$T = \frac{264Q}{\Delta s}$$

Equation C-10

Where, T = transmissivity, in gallons per day per foot

Q = discharge rate, in gallons per minute

Δs = change in head over one log cycle of the graph, in feet

Because many of the test wells completed on the Plateau are severely partially penetrating, an alternate solution considered for assessing aquifer conditions is the Hantush equation for partially penetrating wells (Hantush 1961, 098237; Hantush 1961, 106003). The Hantush equation is as follows:

Equation C-11

$$s = \frac{Q}{4\pi T}\left[W(u) + \frac{2b^2}{\pi^2 (l-d)(l'-d')}\sum_{n=1}^{\infty}\frac{1}{n^2}\left(\sin\frac{n\pi l}{b} - \sin\frac{n\pi d}{b}\right)\left(\sin\frac{n\pi l'}{b} - \sin\frac{n\pi d'}{b}\right)W\left(u, \sqrt{\frac{K_z}{K_r}}\frac{n\pi r}{b}\right)\right]$$

Where, in consistent units, s, Q, T, t, r, S, and u are as previously defined and

b = aquifer thickness

d = distance from top of aquifer to top of well screen in pumped well

l = distance from top of aquifer to bottom of well screen in pumped well

d' = distance from top of aquifer to top of well screen in observation well

l' = distance from top of aquifer to bottom of well screen in observation well

K_z = vertical hydraulic conductivity

K_r = horizontal hydraulic conductivity

In this equation, $W(u)$ is the Theis well function and $W(u,\beta)$ is the Hantush well function for leaky aquifers where:

$$\beta = \sqrt{\frac{K_z}{K_r}}\frac{n\pi r}{b}$$

Equation C-12

Note that for single-well tests, $d = d'$ and $l = l'$.

C-5.0 RECOVERY METHODS

Recovery data were analyzed using the Theis recovery method. This is a semilog analysis method similar to the Cooper-Jacob procedure.

In this method, residual drawdown is plotted on a semilog graph versus the ratio t/t', where t is the time since pumping began and t' is the time since pumping stopped. A straight line of best fit is constructed through the data points and T is calculated from the slope of the line as follows:

$$T = \frac{264Q}{\Delta s}$$

Equation C-13

The recovery data are particularly useful compared to time-drawdown data. Because the pump is not running, spurious data responses associated with dynamic discharge rate fluctuations are eliminated. The result is that the data set is generally “smoother” and easier to analyze.

Recovery data also can be analyzed using the Hantush equation for partial penetration. This approach is generally applied to the early data in a plot of recovery versus recovery time.

C-6.0 SPECIFIC CAPACITY METHOD

The specific capacity of the pumped well can be used to obtain a lower-bound value of hydraulic conductivity. The hydraulic conductivity is computed using formulas that are based on the assumption that the pumped well is 100% efficient. The resulting hydraulic conductivity is the value required to sustain the observed specific capacity. If the actual well is less than 100% efficient, it follows that the actual hydraulic conductivity would have to be greater than calculated to compensate for well inefficiency. Thus, because the efficiency is unknown, the computed hydraulic conductivity value represents a lower bound. The actual conductivity is known to be greater than or equal to the computed value.

For fully penetrating wells, the Cooper-Jacob equation can be iterated to solve for the lower-bound hydraulic conductivity. However, the Cooper-Jacob equation (assuming full penetration) ignores the contribution to well yield from permeable sediments above and below the screened interval. To account for this contribution, it is necessary to use a computation algorithm that includes the effects of partial penetration. One such approach was introduced by Brons and Marting (1961, 098235) and augmented by Bradbury and Rothchild (1985, 098234).

Brons and Marting introduced a dimensionless drawdown correction factor, s_P, approximated by Bradbury and Rothschild as follows:

$$s_P = \frac{1-\frac{L}{b}}{\frac{L}{b}}\left[\ln\frac{b}{r_w} - 2.948 + 7.363\frac{L}{b} - 11.447\left(\frac{L}{b}\right)^2 + 4.675\left(\frac{L}{b}\right)^3\right] \qquad \textbf{Equation C-14}$$

In this equation, L is the well screen length, in ft. Incorporating the dimensionless drawdown parameter, the conductivity is obtained by iterating the following formula:

$$K = \frac{264Q}{sb}\left(\log\frac{0.3Tt}{r_w^2 S} + \frac{2s_P}{\ln 10}\right) \qquad \textbf{Equation C-15}$$

The Brons and Marting procedure can be applied to both partially penetrating and fully penetrating wells.

To apply this procedure, a storage coefficient value must be assigned. Storage coefficient values generally range from 10^{-5} to 10^{-3} for confined aquifers and 0.01 to 0.25 for unconfined aquifers (Driscoll 1986, 104226). Semiconfined conditions generally are associated with intermediate storage coefficient values between these ranges. For R-47, the test data and well log suggested semiconfined to unconfined conditions, so calculations were performed for an assigned storage coefficient range of 0.001 to 0.1. The lower-bound transmissivity calculation result is not particularly sensitive to the choice of storage coefficient value, so a rough estimate is generally adequate to support the calculations.

The analysis also requires assigning a value for the saturated aquifer thickness, b. For R-47, b was assigned a value of 93 ft, the saturated thickness of Puye Formation penetrated by the borehole before backfilling and well completion. The calculation is not particularly sensitive to the assigned value of saturated thickness. It is only necessary to use a value well in excess of the screen length. Ignoring deeper sediments has little effect on the calculation results because sediments far from the screened interval have negligible effect on yield.

C-7.0 BACKGROUND DATA ANALYSIS

Background aquifer pressure data collected during the R-47 tests were plotted along with barometric pressure to determine the barometric effect on water levels.

Figure C-7.0-1 shows aquifer pressure data from R-47 during the test period along with barometric pressure data from TA-54 that have been corrected to equivalent barometric pressure in feet of water at the water table. The R-47 data are referred to in the figure as the “apparent hydrograph” because the measurements reflect the sum of water pressure and barometric pressure, having been recorded using a nonvented pressure transducer. The times of the pumping test periods for the R-47 pumping tests are included on the figure for reference.

A comparison of the apparent hydrograph and barometric pressure curve showed little correlation between the two, suggesting a high barometric efficiency, likely close to 100%. Large changes in barometric pressure caused negligible change in the apparent hydrograph, meaning that the changes in water level were equal and opposite changes in barometric pressure.

The most noticeable feature of the apparent hydrograph is that water levels were continuing to recover from extensive purge pumping that had been performed for four days, ending on October 8 about 2 d before the start of the water-level monitoring depicted on the figure.

C-8.0 WELL R-47 DATA ANALYSIS

This section presents the data obtained from the R-47 pumping tests and the results of the analytical interpretations. Data are presented for trial 1, trial 2 and the 24-h constant-rate test.

C-8.1 Well R-47 Trial 1 Test

Brief trial testing was performed to obtain “snapshots” of early pumping and recovery response to try to quantify properties of the subsurface materials immediately around the wellbore.

Figure C-8.1-1 shows a semilog plot of the drawdown data collected from the trial 1 test on R-47 at a discharge rate of 5.5 gpm. The transmissivity determined from the line of fit on the graph was 1170 gallons per day (gpd)/ft. Based on the well screen length of 21.3 ft, this indicated an average hydraulic conductivity value of 54.9 gpd/ft^2, or 7.3 ft/d.

The early data points on the plot showed exaggerated drawdown. This was likely caused by minor antecedent drainage of the drop pipe through a leaky coupling joint beneath one of the check valves used in the pipe string. Such leakage would leave a void under vacuum conditions in the drop pipe beneath the check valve. On startup, the pump operated against less head initially and produced correspondingly greater discharge (and drawdown) briefly until the void in the drop pipe refilled.

The late data on the plot showed an inexplicable rise in water level. There are multiple possible causes of such a response, including (1) a rate reduction associated with inadvertently disturbing the discharge valve; (2) a small increase in well efficiency caused by production of solids from the screen zone; (3) added resistance to flow resulting from clogging of the water meter with tape, pipe dope, or other obstructions; and (4) added resistance to flow caused by altering the position of the surface discharge hose.

Figure C-8.1-2 shows the recovery data recorded following shutdown of the trial 1 pumping test. The transmissivity determined from the plot was 1080 gpd/ft corresponding to a hydraulic conductivity value of

50.7 gpd/ft^2, or 6.8 ft/d. The early data points showed a flatter slope than the bulk of the data plot. This was likely an artifact of the u value being greater than 0.05, violating one of the assumptions of the semilog method. It is rare to see this effect in the pumped well data, but the low transmissivity value and very early time measurements made it possible.

Because of the limitations of the semilog method in this regard, the data were analyzed using Theis curve matching so that all of the data could be included in the analysis. Figure C-8.1-3 shows the resulting curve match, revealing a calculated transmissivity of 1250 gpd/ft corresponding to a hydraulic conductivity value of 58.7 gpd/ft^2, or 7.8 ft/d. In general, this type of plot requires that recovery time be plotted versus *calculated recovery,* which is the difference between extrapolated drawdown (that would have occurred had pumping continued) and observed residual drawdown. The plot shown, however, shows recovery time plotted versus *recovery* which is the difference between drawdown at the time of pump shutoff and observed residual drawdown. As long as the analysis is limited to relatively early data, this approach is valid and doesn't require having to construct the extrapolated drawdown data set.

Figure C-8.1-3 also shows the results of a calculation of the storage coefficient. This calculation is valid only for data from observation wells or 100% efficient pumped wells. Generally, when the calculation is performed using pumped well data, well inefficiency causes a bias in the calculated storage coefficient resulting in a calculated value less than the true value. Therefore, the storage coefficient indicated on the plot is considered a lower bound. The value obtained from the analysis falls above the confined range and implies semiconfined or unconfined conditions at R-47.

C-8.2 Well R-47 Trial 2 Test

Figure C-8.2-1 shows a semilog plot of the drawdown data collected from the trial 2 test on R-47 at a discharge rate of 5.5 gpm. The transmissivity value determined from the analysis was 1300 gpd/ft corresponding to a hydraulic conductivity value of 61.0 gpd/ft^2, or 8.2 ft/d.

The early data again were affected by antecedent drop pipe drainage precluding the use of data before 0.1 min. The late data showed a steady flattening of the drawdown curve consistent with vertical growth of the cone of depression beyond the limits of the screened interval. This flattening trend could also be caused by delayed yield associated with possible unconfined conditions at R-47. Data from the last 7 or 8 min showed the same inexplicable abrupt rise in level seen in trial 1.

Figure C-8.2-2 shows recovery data recorded for 2 d following cessation of pumping. The transmissivity determined from the slope of the graph was 1190 gpd/ft corresponding to a hydraulic conductivity value of 55.9 gpd/ft^2, or 7.5 ft/d. As indicated on the plot, the very early data could not be analyzed using the semilog method because the u value was greater than 0.05. At late time (left side of graph) the curve flattened for a time, consistent with vertical expansion of the cone of impression or delayed yield, and then steepened significantly. The steep slope was an artifact of running the pumping tests while the water table was still recovering from extensive antecedent development pumping.

The recovery data were analyzed using Theis curve matching to allow incorporating the earliest data points into the analysis. Figure C-8.2-3 shows the resulting curve match yielding an estimated transmissivity of 1350 gpd/ft corresponding to a hydraulic conductivity value of 63.4 gpd/ft^2, or 8.5 ft/d.

C-8.3 Well R-47 24-Hour Constant-Rate Test

Figure C-8.3-1 shows a semilog plot of the drawdown data collected during the 24-h constant-rate pumping test conducted at an average discharge rate of 5.5 gpm. The transmissivity of the screened

interval determined from the plot was 1230 gpd/ft corresponding to a hydraulic conductivity value of 57.7 gpd/ft^2, or 7.7 ft/d.

Late data showed a flattening of the drawdown graph, consistent with either delayed yield or vertical expansion of the cone of depression beyond the screened zone. The transmissivity computed from the late-time slope was 4150 gpd/ft. If vertical growth of the cone of depression were the sole contributor to the observed slope change, this computed value could represent the transmissivity of a hydraulically contiguous interval of sediments thicker than the screened interval, but of unknown thickness. On the other hand, if delayed yield is present, the computed value would not reflect any specific aquifer property but simply would reflect the temporary retardation of the growth of the cone of depression caused by vertical movement of the water table.

The early data on Figure C-8.3-1 showed unusual response associated with (1) antecedent drop pipe drainage through a leaky coupling downhole as well as (2) refilling of drop pipe at the surface that had been deliberately drained below the frost line to prevent freezing overnight. The initial steep slope reflected the greatest discharge rate that was achieved when the pump operated against the head of water in the drop pipe between the water table and the elevation of the void in the drop pipe. Once that void was filled, the head increased to an amount equal to the distance from the water table to near land surface. This head increase resulted in a sudden decline in discharge rate, allowing water levels to recover briefly (indicated by the rise in levels shown on the data plot between 0.04 and 0.07 min). Continued pumping resulted in water levels declining again as shown by the data between times of 0.07 and 0.14 min. At 0.15 min, the deliberately drained portion of the drop pipe at ground surface finally filled all the way to the control valve. At this point, added resistance caused by the partially closed control valve suddenly reduced the discharge rate again as evidenced by another rise in water levels. This rise was temporary because continued pumping reversed the trend and drawdown began increasing again.

An attempt was made to compute aquifer transmissivity using the initial drawdown response (the first 10 data points on Figure C-8.3-1 corresponding to the first 0.04 min [2.4 s] of pumping). This was done because the earliest response is indicative of the properties of just the screened interval and sure to be free of the effects of vertical growth of the cone of depression. The procedure used to accomplish this was as follows.

First, it was necessary to estimate the discharge rate during this early period. This was done by comparing the observed drawdown after 0.04 min with the value obtained by extrapolating the slope of the time-drawdown graph backward in time to 0.04 min. The extrapolated value was considered representative of the drawdown that would have been observed at 5.5 gpm had there been no voids in the drop pipe. The comparison showed that the observed drawdown was approximately 2.4 times greater than the extrapolated value. This implied that the initial discharge rate was about 2.4 times greater than the test rate of 5.5 gpm, or approximately 13 gpm. Inspection of the manufacturer's performance curve for the test pump installed in the well indicated that the pump would produce approximately 13 gpm if the drained void were roughly in the middle of the drop pipe string so that the pump operated initially against a head of approximately 700 ft.

The early data were analyzed by Theis curve matching as shown on Figure C-8.3-2. To achieve this data plot, it was necessary to adjust the time values. Data were collected at 0.25-s intervals, but the elapsed time corresponding to the first data point was not known because it was not possible to synchronize the transducer data collection timing and pump startup precisely. Therefore, the first data point could represent a pumping time anywhere between 0 and 0.25 s. In Figure C-8.3-1, the first data point (nominally 0.25 s) showed only 0.27 ft of drawdown, whereas the next data point (0.25 s later) showed 1.14 ft of drawdown, an increase of 0.87 ft. Each consecutive 0.25-s interval should produce progressively less drawdown than the previous one and, thus, it is clear that the pumping time

corresponding to the first data point of 0.27 ft of drawdown must have been just a fraction of 0.25 s. To adjust for this, the time parameters were recomputed for various assumed starting times. The offset in starting time was varied until the complete set of 10 data points fit a standard Theis type curve while making sure that the time of the first data point did not exceed a fraction of 0.25 s. Figure C-8.3-2 shows the resulting data plot and the computed transmissivity value of 1030 gpd/ft corresponding to a hydraulic conductivity value of 48.4 gpd/ft^2, or 6.5 ft/d.

Figure C-8.3-3 shows recovery data collected following shutdown of the 24-h test. The transmissivity determined from the data plot was 1070 gpd/ft, corresponding to a hydraulic conductivity value of 50.2 gpd/ft^2, or 6.7 ft/d. Note that at early recovery time (right side of graph) the data points did not fall on the line of fit because the u value was greater than 0.05. At late time, the curve flattened in response to either delayed yield and/or vertical expansion of the cone of impression. The stabilized straight line segment in this area of the plot showed a transmissivity of 4610 gpd/ft. This value could represent the transmissivity of an unknown thickness of hydraulically contiguous sediments greater than the 21.3-ft well screen length or simply reflect a combination of delayed yield and vertical growth of the cone of impression.

The recovery data were analyzed using Theis curve matching to allow incorporating the earliest data points into the analysis. Figure C-8.3-4 shows the resulting curve match yielding an estimated transmissivity of 1200 gpd/ft corresponding to a hydraulic conductivity value of 56.3 gpd/ft^2, or 7.5 ft/d.

C-8.4 Combined Results

Table C-8.4-1 summarizes the results of the analyses determining the hydraulic properties of the screened zone in R-47. Transmissivity values ranged from 1030 to 1350 gpd/ft, averaging 1190 gpd/ft. The resulting hydraulic conductivity values ranged from 6.5 to 8.5 ft/d, averaging 7.5 ft/d.

C-8.5 Packer Deflation

Following the 24-h recovery period ending at 8:00 a.m. on October 15, 2014, the packer was deflated slowly and water-level monitoring continued for 30 min before the pump was pulled to check for water accumulation above the packer during the test.

Figure C-8.5-1 shows the observed water level response when the packer was deflated. The spike in water level was caused by trapped water above the packer that had flowed into the annulus through a leaky coupling in the drop pipe during testing. Once the packer was deflated, this trapped water moved downward into the well screen, causing the observed head buildup seen on the graph.

This response was consistent with the observation of exaggerated drawdown early in all of the pumping events and confirmed that leakage of water from the drop pipe creating a void beneath a check valve caused this response.

C-8.6 Well R-47 Specific Capacity Data

Specific capacity data were used along with well geometry to estimate a lower-bound hydraulic conductivity value for the permeable zone penetrated by R-47 to provide a frame of reference for evaluating the foregoing analyses.

The total saturated thickness of Puye sediments was not known. In applying partial penetration analysis, however, it is only necessary to assign an aquifer thickness substantially greater than the well screen

length because sediments far from the screened interval have negligible effect on yield. The aquifer thickness was arbitrarily assigned a value of 93 ft—the length of saturated sediments penetrated during drilling of the borehole. The well screen length of 21.3 ft was used in the partial penetration calculations.

R-47 produced 5.5 gpm with 5.4 ft of drawdown for a specific capacity of 1.02 gpm/ft after 1440 min of pumping. In addition to specific capacity and pumping time, other input values used in the calculations included assigned storage coefficient values ranging from 0.001 to 0.1 and a borehole radius of 0.71 ft (inferred from the volume of filter pack required to backfill the screen zone).

Applying the Brons and Marting method to these inputs yielded the lower-bound hydraulic conductivity estimates shown on Figure C-8.6-1. Depending on the assumed storage coefficient value, the calculated lower-bound hydraulic conductivity values ranged from approximately 5 to 6 ft/d, consistent with the values obtained from test analysis that produced hydraulic conductivity values ranging from 6.5 to 8.5 ft/d and averaging 7.5 ft/d.

C-9.0 SUMMARY

Constant-rate pumping tests were conducted on R-47 to gain an understanding of the hydraulic characteristics of the screened interval.

A comparison of barometric pressure and R-47 water level data showed a highly barometrically efficient screen zone. Large changes in barometric pressure caused almost no change in the apparent hydrograph obtained from the well.

Early data supported a determination of aquifer properties, while late data showed a flattening of the time-drawdown and recovery graphs consistent with vertical expansion of the cone of depression and/or delayed yield effects associated with unconfined aquifer conditions. Transmissivity values for the screened interval determined from the analyses ranged from 1030 to 1350 gpd/ft, averaging 1190 gpd/ft. The corresponding hydraulic conductivity values ranged from 6.5 to 8.5 ft/d, averaging 7.5 ft/d.

Late drawdown and recovery data from the 24-h test yielded an average transmissivity value of 4380 gpd/ft possibly corresponding to the cone of depression expanding into a greater thickness of permeable sediments. This result may be of questionable validity, however, because the data on which it was based were not only affected by vertical expansion of the cone of depression but also by superposition of the effects of unknown aquifer heterogeneity, possible continued delayed yield, and ongoing recovery from the antecedent development pumping performed on R-47. Furthermore, there was no way to identify a corresponding aquifer thickness to allow estimation of a hydraulic conductivity value.

The specific capacity of the well implied lower-bound hydraulic conductivity values in the range of 5 to 6 ft/d consistent with the results of the hydraulic analyses.

C-10.0 REFERENCES

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

Bradbury, K.R., and E.R. Rothschild, March-April 1985. “A Computerized Technique for Estimating the Hydraulic Conductivity of Aquifers from Specific Capacity Data,” *Ground Water,* Vol. 23, No. 2, pp. 240-246. (Bradbury and Rothschild 1985, 098234)

Brons, F., and V.E. Marting, 1961. “The Effect of Restricted Fluid Entry on Well Productivity,” *Journal of Petroleum Technology,* Vol. 13, No. 2, pp. 172-174. (Brons and Marting 1961, 098235)

Cooper, H.H., Jr., and C.E. Jacob, August 1946. “A Generalized Graphical Method for Evaluating Formation Constants and Summarizing Well-Field History,” *American Geophysical Union Transactions,* Vol. 27, No. 4, pp. 526-534. (Cooper and Jacob 1946, 098236)

Driscoll, F.G., 1986. Excerpted pages from *Groundwater and Wells*, 2nd Ed., Johnson Filtration Systems Inc., St. Paul, Minnesota. (Driscoll 1986, 104226)

Hantush, M.S., July 1961. “Drawdown around a Partially Penetrating Well,” *Journal of the Hydraulics Division, Proceedings of the American Society of Civil Engineers,* Vol. 87, No. HY 4, pp. 83-98. (Hantush 1961, 098237)

Hantush, M.S., September 1961. “Aquifer Tests on Partially Penetrating Wells,” Journal of the Hydraulics Division, Proceedings of the American Society of Civil Engineers, pp. 171–195. (Hantush 1961, 106003)

Schafer, D.C., January-February 1978. "Casing Storage Can Affect Pumping Test Data," *The Johnson Drillers Journal,* pp. 1-6, Johnson Division, UOP, Inc., St. Paul, Minnesota. (Schafer 1978, 098240)

Theis, C.V., 1934-1935. “The Relation Between the Lowering of the Piezometric Surface and the Rate and Duration of Discharge of a Well Using Ground-Water Storage,” *American Geophysical Union Transactions,* Vol. 15-16, pp. 519-524. (Theis 1934-1935, 098241)

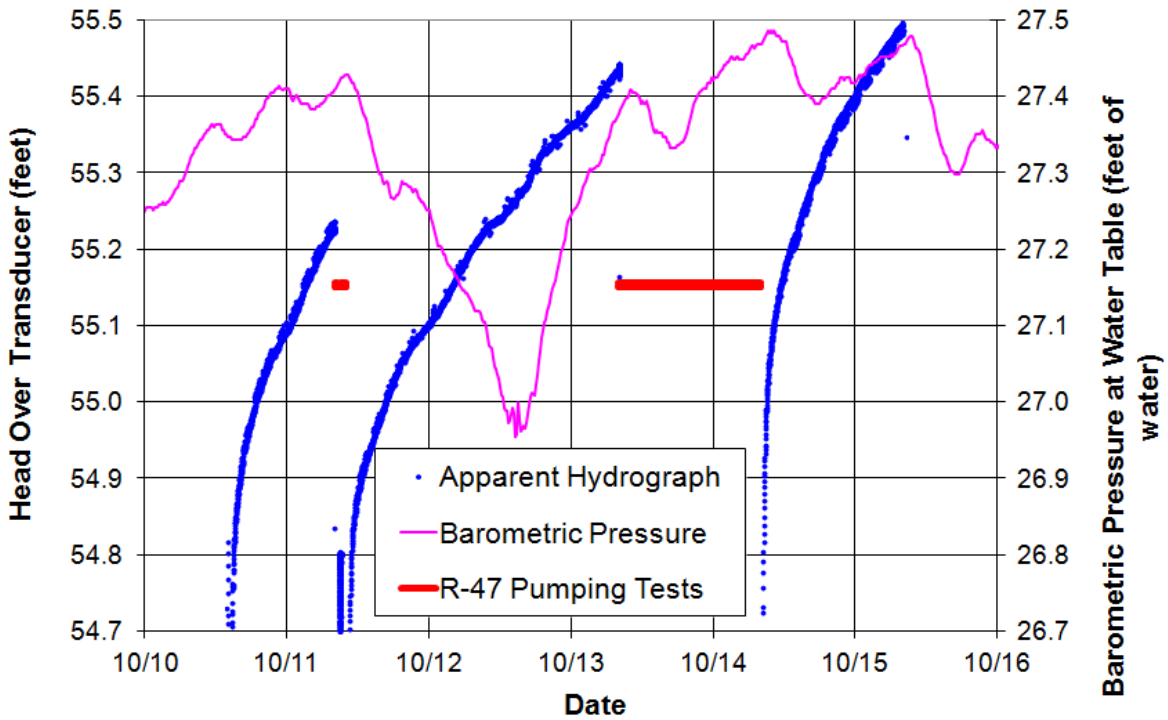


Figure C-7.0-1 Well R-47 apparent hydrograph

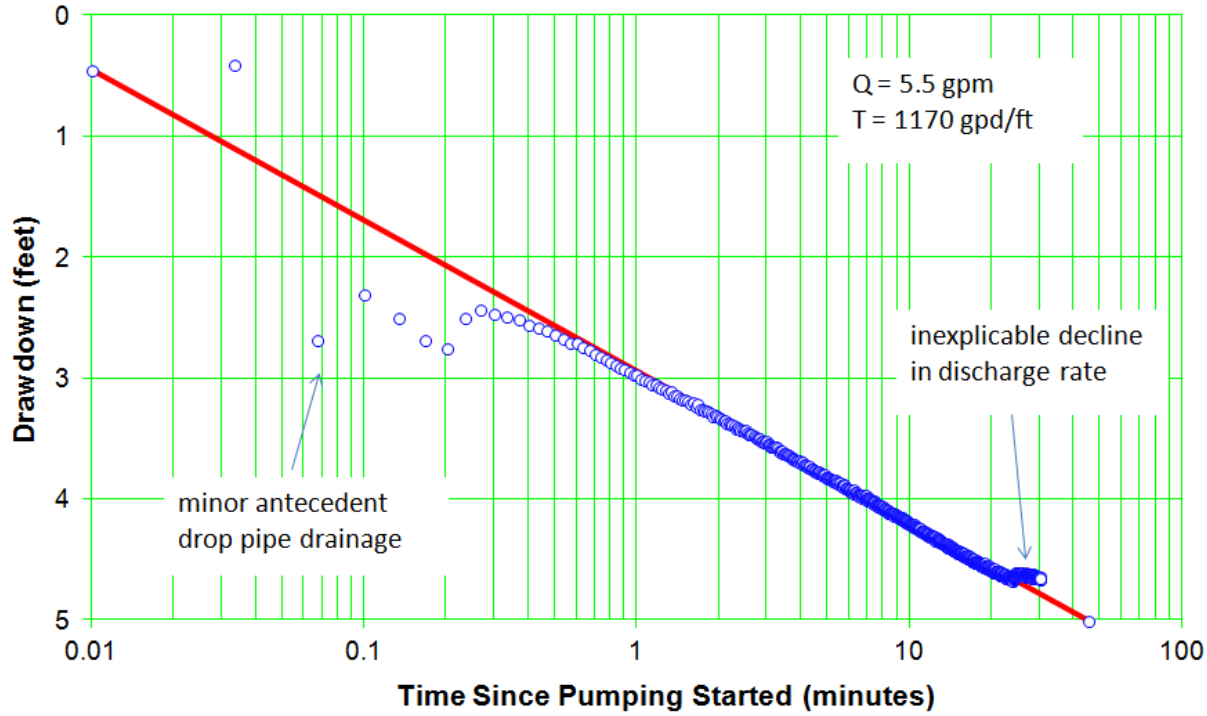


Figure C-8.1-1 Well R-47 trial 1 drawdown

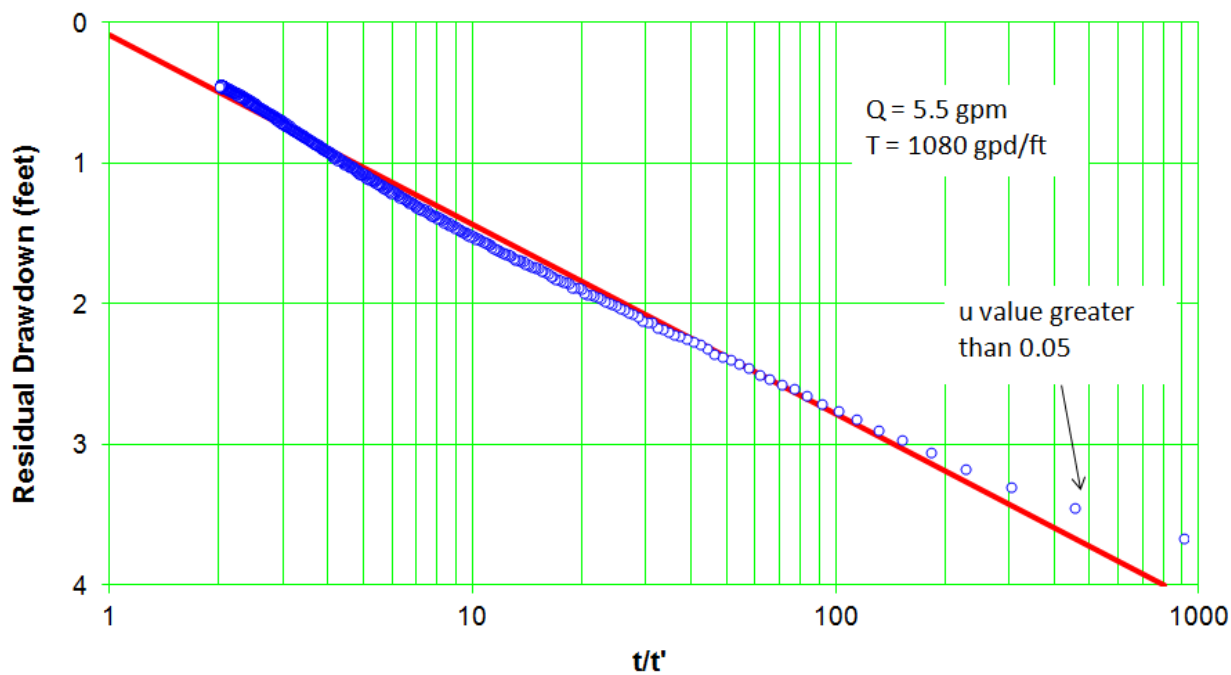


Figure C-8.1-2 Well R-47 trial 1 recovery

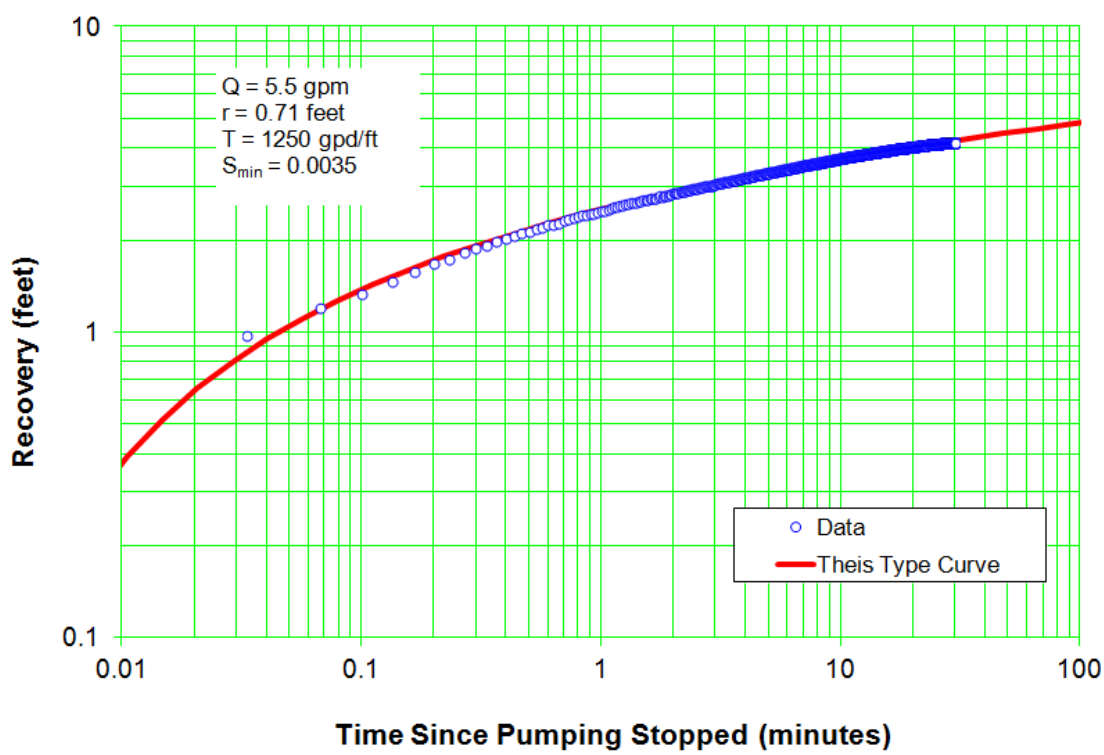


Figure C-8.1-3 Log-log plot of well R-47 trial 1 recovery

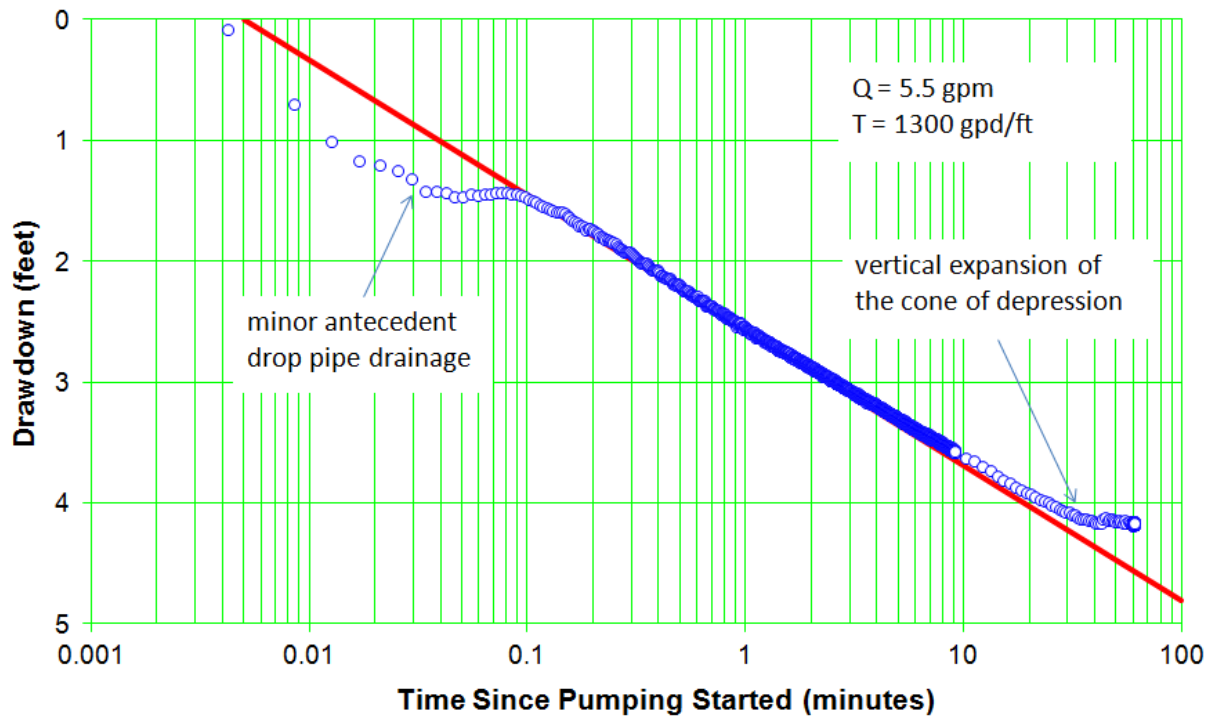


Figure C-8.2-1 Well R-47 trial 2 drawdown

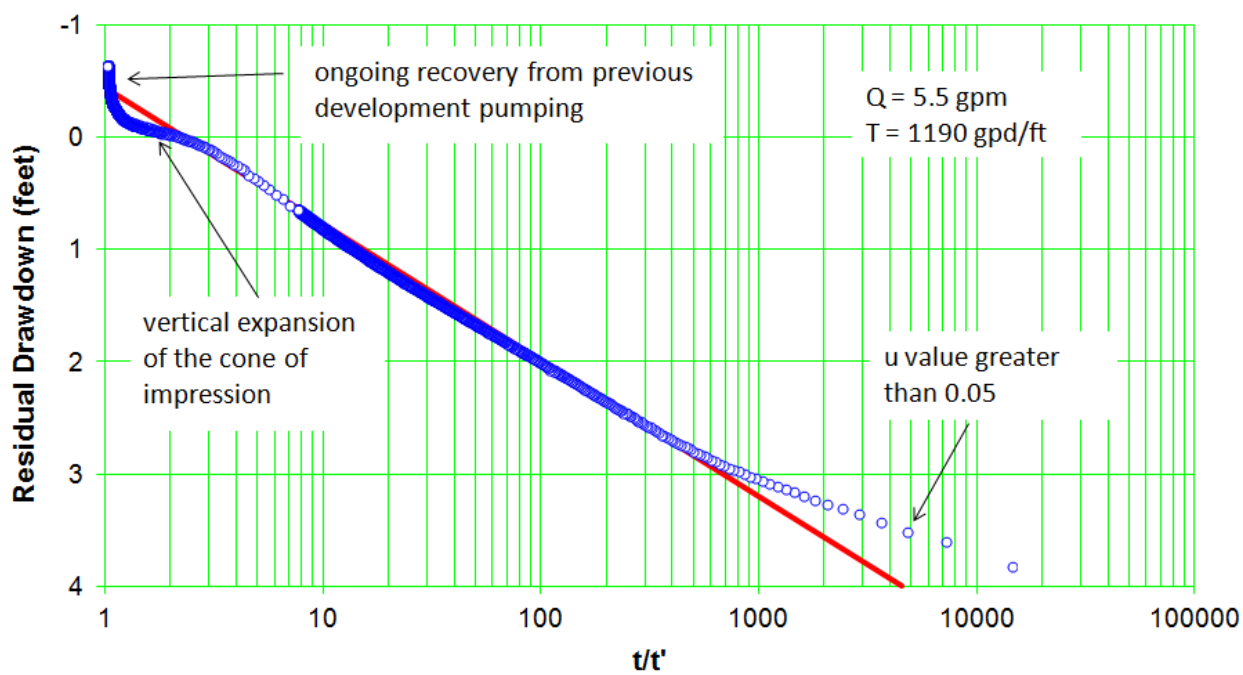


Figure C-8.2-2 Well R-47 trial 2 recovery

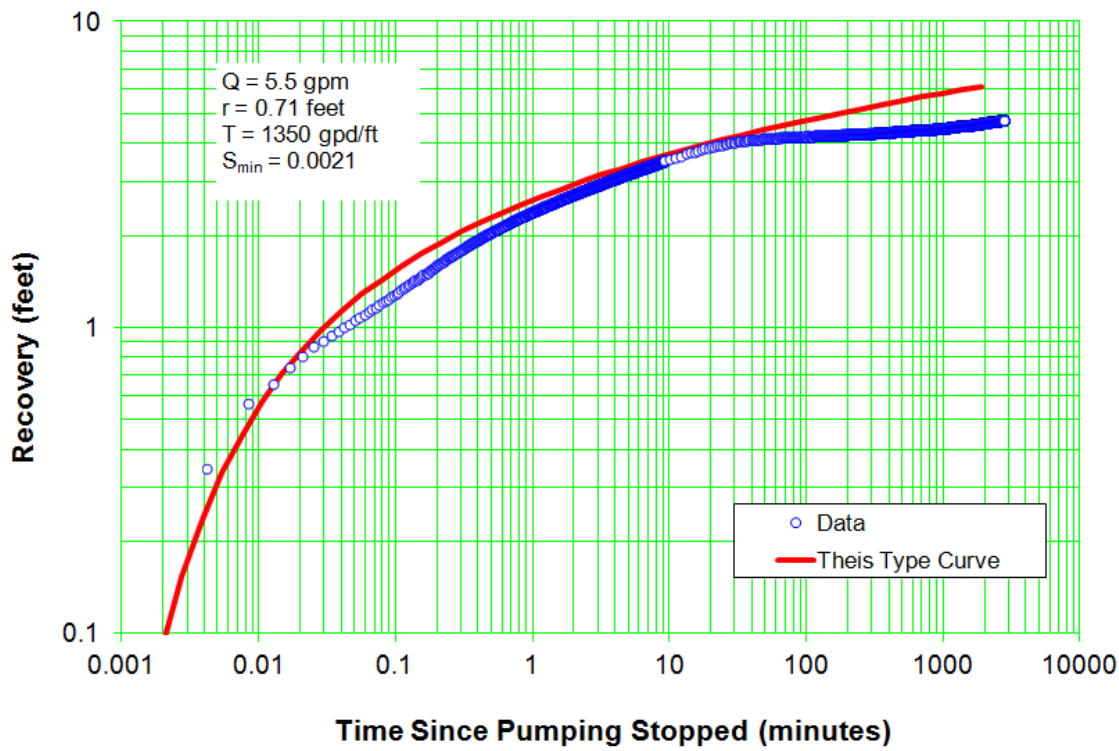


Figure C-8.2-3 Log-log plot of well R-47 trial 2 recovery

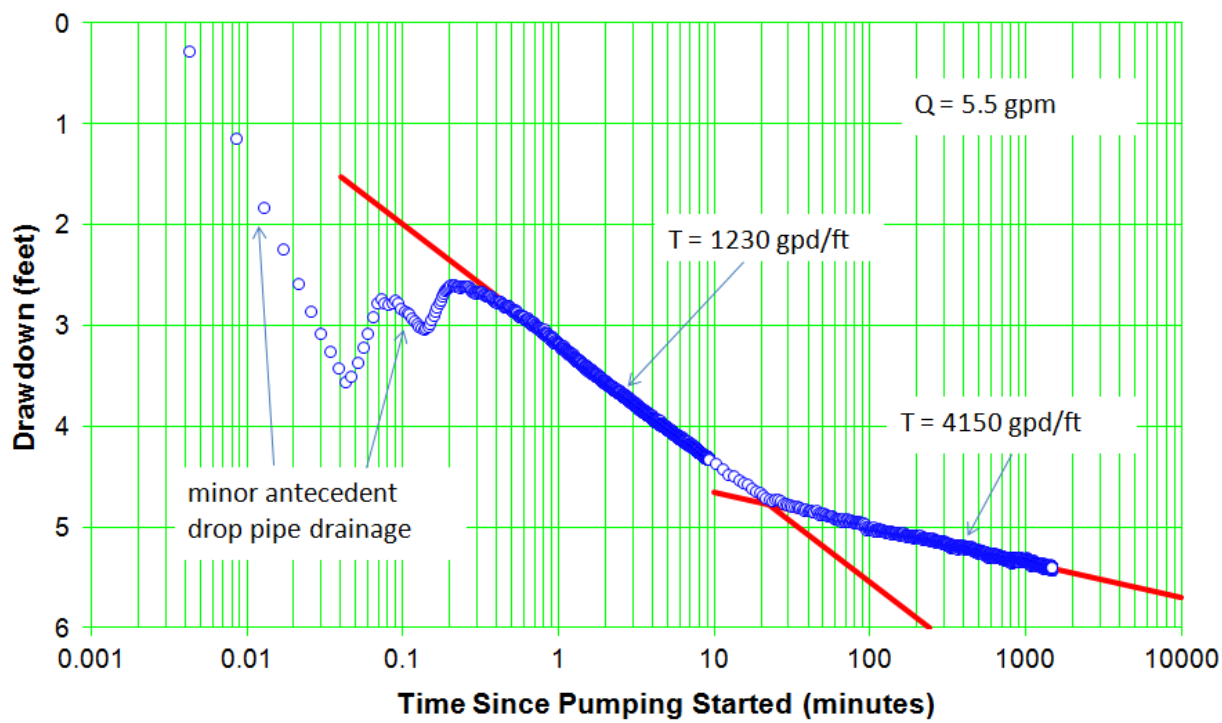


Figure C-8.3-1 Well R-47 drawdown

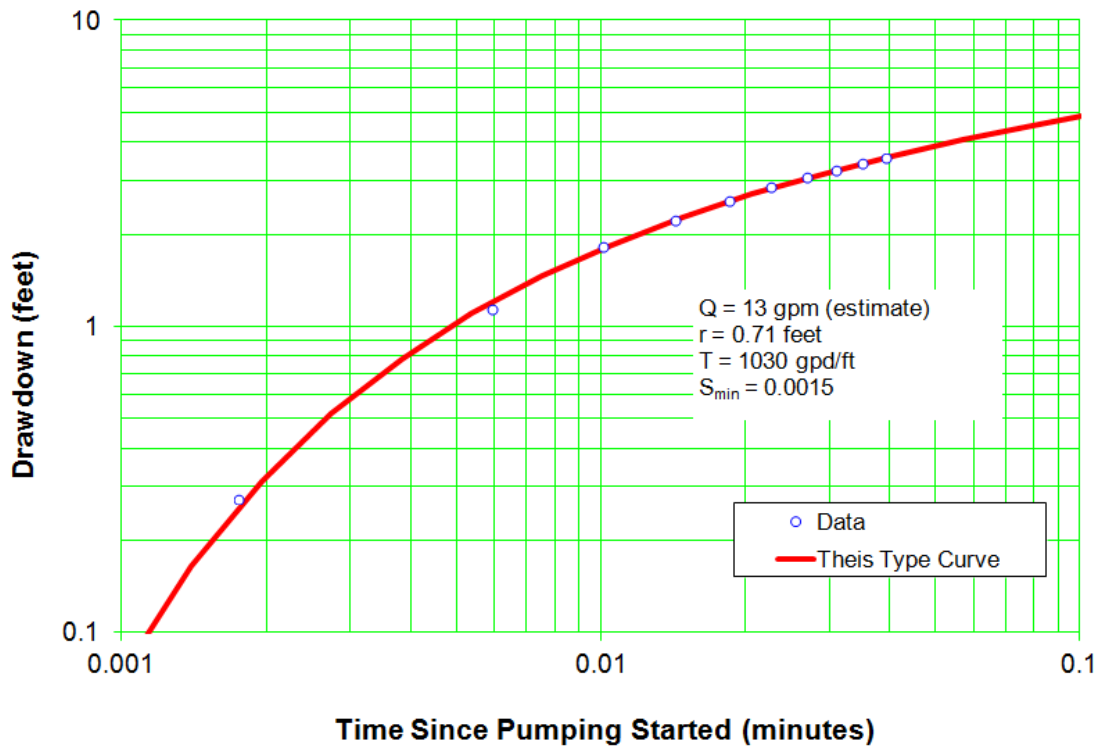


Figure C-8.3-2 Log-log plot of well R-47 drawdown

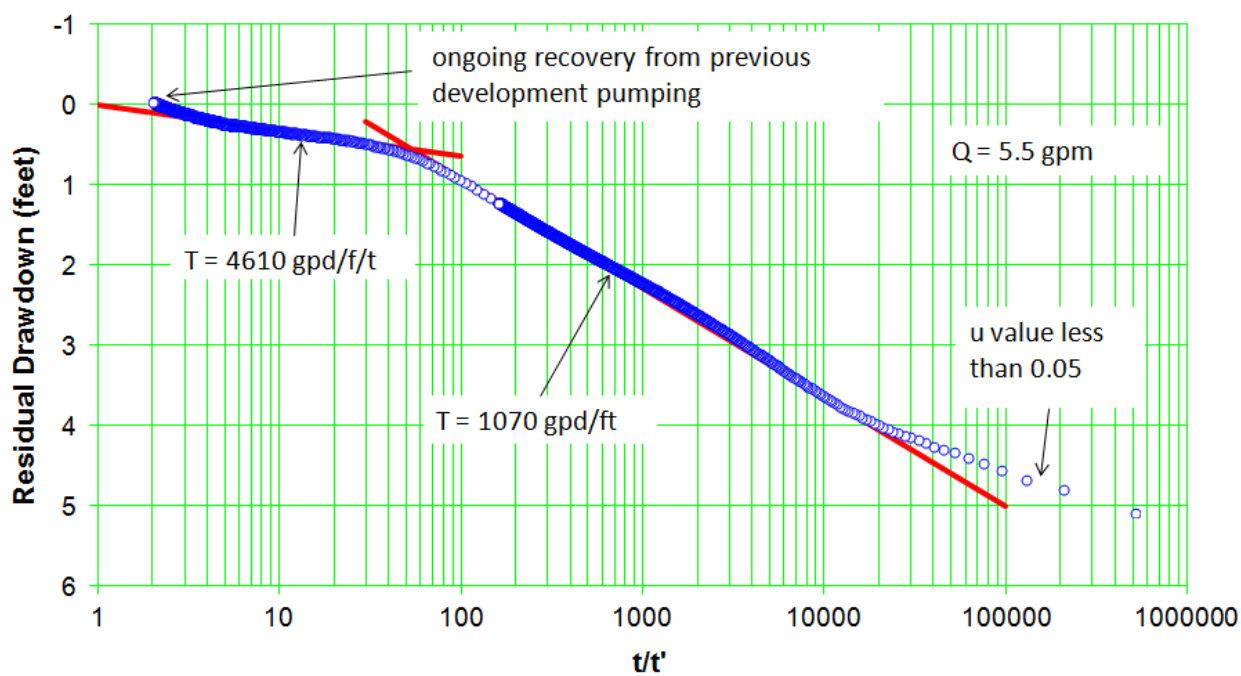


Figure C-8.3-3 Well R-47 recovery

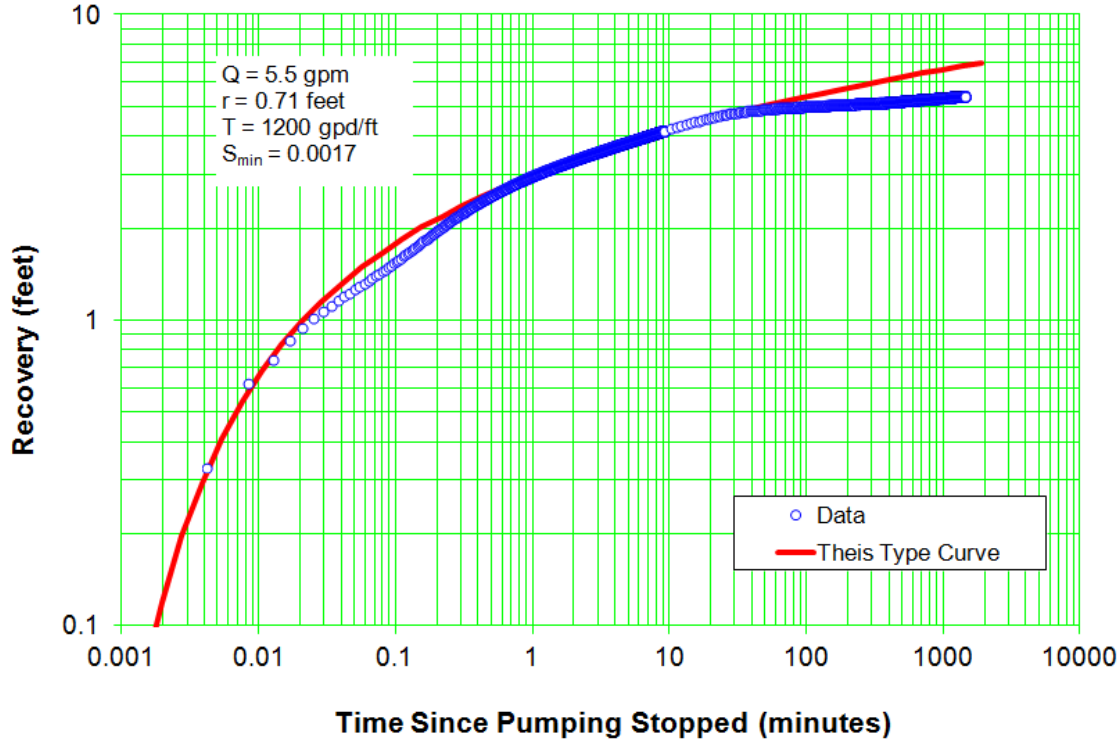


Figure C-8.3-4 Log-log plot of well R-47 recovery

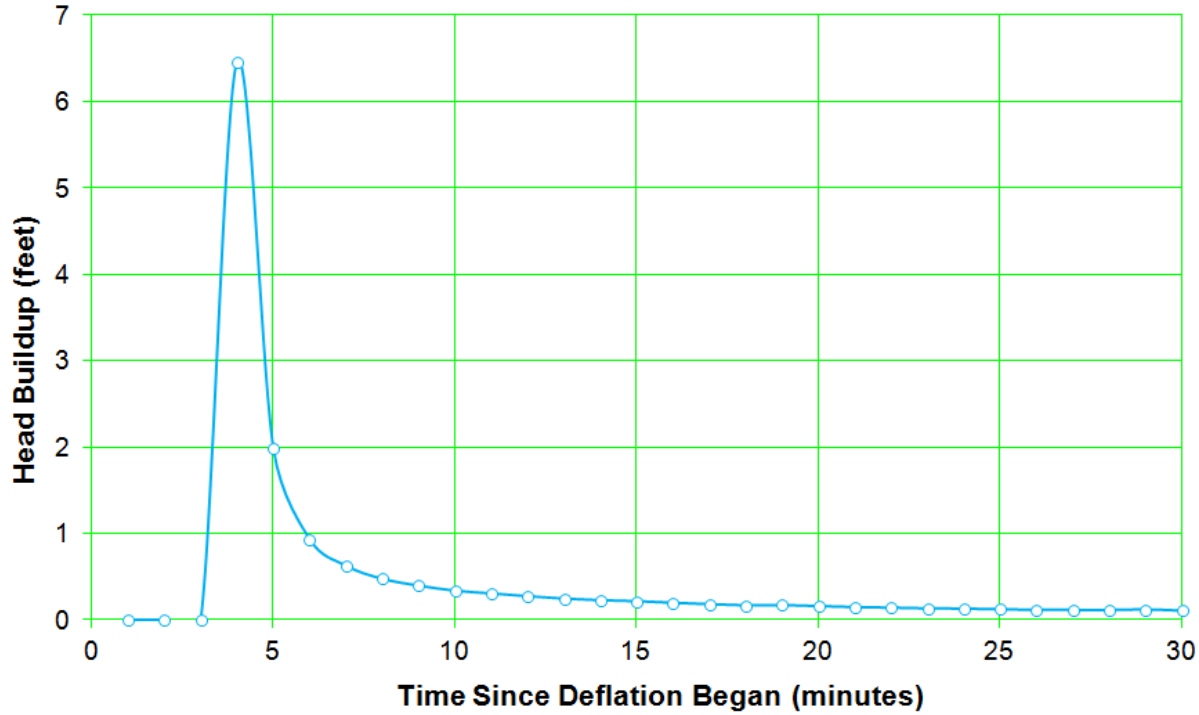


Figure C-8.5-1 Well R-47 packer deflation response

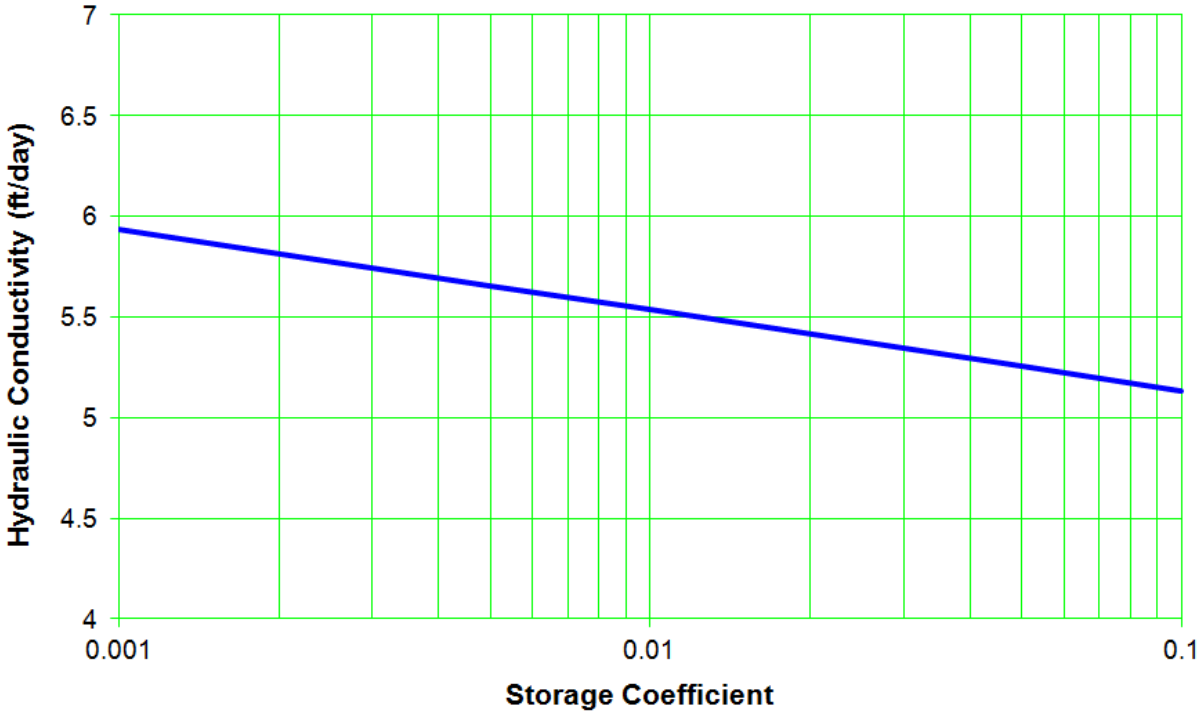


Figure C-8.6-1 Well R-47 lower-bound hydraulic conductivity

Table C-8.4-1
Aquifer Parameter Values

Test	Method	T (gpd/ft)	K (gpd/ft^2)	K (ft/d)
Trial 1	Drawdown	1170	54.9	7.3
Trial 1	Residual drawdown	1080	50.7	6.8
Trial 1	Early recovery	1250	58.7	7.8
Trial 2	Drawdown	1300	61.0	8.2
Trial 2	Residual drawdown	1190	55.9	7.5
Trial 2	Early recovery	1350	63.4	8.5
24 Hour	Drawdown	1230	57.7	7.7
24 Hour	Early drawdown	1030	48.4	6.5
24 Hour	Residual drawdown	1070	50.2	6.7
24 Hour	Early recovery	1200	56.3	7.5
Average of all tests	**All**	**1190**	**55.9**	**7.5**

Appendix D

Final Well Design and
New Mexico Environment Department Approval

R-47 Well Objectives

Regional aquifer well R-47 is being installed to satisfy a recommendation made in the Technical Area 16 Well Network Evaluation and Recommendations (LANL 2012, 213573) and approved by the New Mexico Environment Department (NMED) Hazardous Waste Bureau. This assessment recommended installing one new regional groundwater monitoring well to augment the existing network to better define RDX (hexahydro-1,3,5-trinitro-1,3,5-triazine) contamination flow paths within the regional aquifer north of Cañon de Valle (Figure 1). The primary purpose of R-47 is to provide groundwater monitoring for high explosives (HE) and other potential contaminants in the regional aquifer downgradient of the 260 Outfall and beneath infiltration pathways associated with Cañon de Valle and perched groundwater systems in the area.

R-47 Recommended Well Design

It is recommended that R-47 be installed as a single-screen well with a 20-ft stainless-steel, 40 slot, wire-wrapped well screen extending from 1322 ft to 1342 ft bgs. The depth to top of regional saturation is ~1307 feet. The primary filter packs for the screen will consist of 10/20 sand extending 5 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 the attached figure.

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

R-47 Well Design Considerations

Preliminary lithologic logs indicate that the geologic units encountered while drilling the R-47 borehole include the Tshirege Member of the Bandelier Tuff (surface to 315 ft), Cerro Toledo interval (315-555 ft), Otowi Member of the Bandelier Tuff (555-730 ft), and Puye Formation (730-1397 ft). The top of regional saturation is within the Puye Formation.

Perched water was anticipated, however there were no indications of perched water at R-47. When drilling was terminated at 847 ft bgs and before 16-inch casing was installed, water was observed standing in the borehole. However, when this water was blown out and the borehole was interrogated over a period of ~6 hours it was observed to be completely dry, indicating that the water observed had been added during drilling. Over the next 460 ft of drilling with casing-advance methods, the borehole was repeatedly circulated and blown dry with no indication of formation water.

Examination of cuttings from the lower interval of the Puye Formation at R-47 indicates typical Tschicoma-derived intermediate volcanic lithologies. The saturated interval of the Puye was relatively uniform with cobbles and boulders in a matrix of sands, gravels, and silts. There is no indication of clay-rich intervals within this interval of the Puye Formation. The screen is located at 1322-1342 ft to provide sufficient submergence for well development while retaining a close proximity to the top of regional saturation

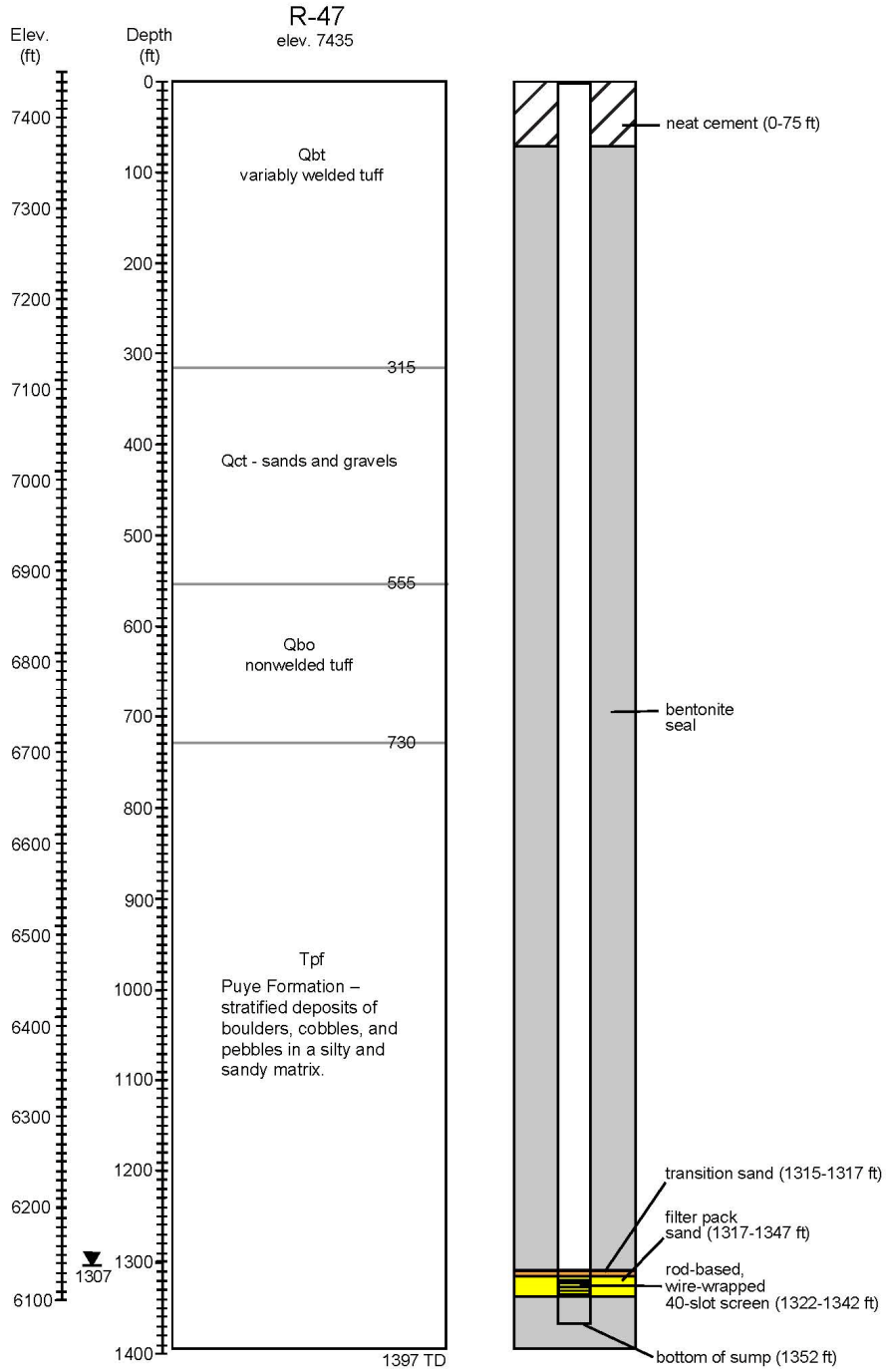


Figure. Proposed well design, R-47

From: Dale, Michael, NMENV [mailto:Michael.Dale@state.nm.us]
Sent: Friday, September 12, 2014 2:46 PM
To: Everett, Mark Capen
Cc: Kulis, Jerzy, NMENV; Wear, Benjamin, NMENV; Cobrain, Dave, NMENV; Rodriguez, Cheryl L; Shen, Hai; Katzman, Danny; Thacker, Mark Sloan; Paris, Steven M; Douglass, Craig R; Woodworth, Woody; Thomson, Jim; Rhodes, David
Subject: RE: R-47 proposed design rev.1

Mark,

NMED has reviewed the proposed R-47 well-construction completion design as presented/attached in your e-mail received today, September 12, 2014 at 2:28 pm. NMED hereby approves the installation of R-47 as proposed in your e-mail. 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-47 as soon as such data or information becomes available. Please contact NMED prior to the final development pumping phase and at the end of aquifer testing at R-47 so that NMED can collected independent groundwater samples for laboratory analyses.

Please let me know if you have any questions.

Michael Dale
New Mexico Environment Department
1183 Diamond Drive, Suite B
Los Alamos, NM 87544
LANL MS M894
Cell Phone: (505) 231-5423
Office Phone (505) 661-2673

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From: Everett, Mark Capen [meverett@lanl.gov]
Sent: Friday, September 12, 2014 2:28 PM
To: Dale, Michael, NMENV
Cc: Kulis, Jerzy, NMENV; Wear, Benjamin, NMENV; Cobrain, Dave, NMENV; Rodriguez, Cheryl L; Shen, Hai; Katzman, Danny; Thacker, Mark Sloan; Paris, Steven M; Douglass, Craig R; Woodworth, Woody; Thomson, Jim; Rhodes, David; Katzman, Danny
Subject: Fw: R-47 proposed design rev.1

Michael,

Here is the revised well design with reference to R-61, the incorrect well, removed.

Please respond with your concurrence.

Thanks,

Mark

Sent from my BlackBerry 10 smartphone on the Verizon Wireless 4G LTE network.
From: MARK EVERETT <meverett_9@msn.com>
Sent: Friday, September 12, 2014 2:23 PM
To: Everett, Mark Capen
Subject: R-47 proposed design rev.1

Appendix E

Borehole Video Logging
(on DVD included with this document)

TO VIEW THE VIDEO THAT ACCOMPANIES THIS DOCUMENT, PLEASE CALL THE HAZARDOUS WASTE BUREAU AT 505-476-6000 TO MAKE AN APPOINTMENT