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Completion Report for Regional Aquifer Well R-52

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EXECUTIVE SUMMARY

This well completion report describes the drilling, installation, development, and aquifer testing of dual-screen regional groundwater monitoring well R-52, located within Los Alamos National Laboratory Technical Area 54. This report was written in accordance with the requirements in Section IV.A.3.e.iv of the Compliance Order on Consent. The well was installed at the direction of the New Mexico Environment Department (NMED) for the collection of groundwater data downgradient of Material Disposal Areas H and J.

The R-52 borehole was drilled using fluid-assisted dual-rotary and standard air-rotary drilling methods. Drilling fluid additives used included potable water and foam. Injection of foam was discontinued at 915 ft below ground surface (bgs), roughly 100 ft above the anticipated top of the regional aquifer. The R-52 borehole was advanced to a total depth of 1175.0 ft bgs using a combination of dual-rotary casing advance and open-hole drilling methods.

During drilling, 24-in. casing was advanced through alluvium and the Tshirege Member of the Bandelier Tuff to 63.8 ft bgs. A 17-in. borehole was advanced through the Bandelier Tuff to a depth of 553 ft bgs, overreamed with a 22-in. borehole to 560 ft bgs, and 18-in. casing was set to 560 ft bgs. The borehole was then advanced open-hole using a combination of bit sizes through a small interval of the Puye Formation, the Cerros del Rio volcanic rocks, and back into the Puye Formation to a depth of 955.0 ft bgs, but was eventually overreamed with a 15.5-in. bit to 945.7 ft bgs. At this point, a retractable 12-in. casing was advanced through the Puye Formation to a total depth of 1175.0 ft bgs. The R-52 monitoring well was completed with two screened intervals, an upper 20-ft screen and a lower 10-ft screen. The lower screened interval is from 1107.0 to 1117.0 ft bgs, and the upper screened interval is from 1035.2 to 1055.7 ft bgs. The composite depth to water after well installation and development was measured at 1018.0 ft bgs.

The well was completed in accordance with the NMED-approved well design. Hydrogeologic testing indicated that the well is productive and will perform effectively to meet planned objectives. Groundwater sampling at R-52 will be performed as part of the facility-wide groundwater-monitoring program.

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Acronyms and Abbreviations

amsl	above mean sea level
ASTM	American Society for Testing and Materials
bgs	below ground surface
BETCO	Barometric and Earth Tide Response Correction (software)
Consent Order	Compliance Order on Consent
DO	dissolved oxygen
DTW	depth to water
EES-14	Earth and Environmental Sciences Group 14
Eh	oxidation-reduction potential
EP	Environmental Programs (Directorate)
EPA	Environmental Protection Agency (U.S.)
gpm	gallons per minute
HE	high explosives
HMX	octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine
IC	ion chromatography

I.D.	inside diameter
LANL	Los Alamos National Laboratory
LH3	low-level tritium
MDA	material disposal area
µS/cm	microsiemens per centimeter
mV	millivolt
NAD	North American Datum
NMED	New Mexico Environment Department
NTU	nephelometric turbidity unit
O.D.	outside diameter
ORP	oxidation-reduction potential
PETN	pentaerythritol tetranitrate
pH	potential of hydrogen
PVC	polyvinyl chloride
Qal	alluvium
Qbo	Otowi Member of the Bandelier Tuff
Qbog	Guaje Pumice Bed of Otowi Member of the Bandelier Tuff
Qbt	Tshirege Member of the Bandelier Tuff
Qct	Cerro Toledo interval
QP	quality procedure
RCRA	Resource Conservation and Recovery Act
RDX	hexahydro-1,3,5-trinitro-1,3,5-triazine
RPF	Records Processing Facility
TA	technical area
TATB	triaminotrinitrobenzene
Tb 4	Cerros del Rio volcanic rocks
TD	total depth
TOC	total organic carbon
Tpf	Puye Formation
TU	tritium unit
VOC	volatile organic compound
WCSF	waste characterization strategy form
WES-EDA	Waste and Environmental Services Division–Environmental Data and Analysis
wt%	weight percent

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-52. The report is written in accordance with the requirements in Section IV.A.3.e.iv of the Compliance Order on Consent (the Consent Order). The R-52 borehole was drilled from January 9 to February 6, 2010, and completed from March 21 to April 5, 2010, at Los Alamos National Laboratory (LANL or the Laboratory) for the Environmental Programs (EP) Directorate.

Well R-52 is located within Technical Area 54 (TA-54) south of Cañada del Buey (Figure 1.0-1). The primary purpose of well R-52 is to collect background groundwater quality data downgradient of Material Disposal Areas (MDAs) H and J. Data from R-52 will supplement data from downgradient well R-37. Additionally, water-level measurements obtained from R-52 during drilling will help determine the lateral extent of the perched-water zone encountered during drilling at well R-37 and establish groundwater levels for the regional aquifer in this area.

The borehole was advanced to a total depth (TD) of 1175.0 ft below ground surface (bgs) and completed with two screened intervals, an upper 20-ft screen and lower 10-ft screen, in the regional aquifer. The lower screen was installed from 1107.0 to 1117.0 ft bgs, and the upper screen was installed from 1035.2 to 1055.7 ft bgs. The composite depth to water (DTW) after well installation and development was 1018.0 ft bgs as measured April 20, 2010. Cuttings samples were collected for lithologic evaluation at 5-ft intervals in the R-52 borehole from ground surface to TD. Postinstallation activities included well development, aquifer testing, surface completion, and geodetic surveying. 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 (RPF). This report contains brief descriptions of activities and supporting figures, tables, and appendixes associated with the R-52 well installation project. Information on radioactive materials and radionuclides, including the results of sampling and analysis of radioactive constituents, is voluntarily provided to the New Mexico Environment Department (NMED) in accordance with U.S. Department of Energy policy.

2.0 PRELIMINARY ACTIVITIES

Preliminary activities included preparing administrative planning documents and preparing the drill site and drill pad. All preparatory activities were completed in accordance with Laboratory policies, procedures, and regulatory requirements.

2.1 Administrative Preparation

The following documents helped guide the implementation of the scope of work for well R-52:

- "Drilling Work Plan for Regional Aquifer Well R-52" (LANL 2009, 107685)
- "Well R-52 Drill Plan, Installation of Well R-52, TA-54, Los Alamos National Laboratory, Revision 1" (North Wind Inc. 2009, 109445)
- "Integrated Work Document for Regional and Intermediate Aquifer Well Drilling" (LANL 2007, 100972)

- "Storm Water Pollution Prevention Plan for SWMUs and AOCs (Sites) and Storm Water Monitoring Plan" (LANL 2006, 092600)
- "Waste Characterization Strategy Form for TA-54 Wells R-51 (Well D) and R-52 (Well A) Regional Well Installation and Corehole Drilling" (LANL 2009, 107439)

2.2 Site Preparation

Laboratory personnel prepared the drill pad several weeks before mobilization. The drill rig, air compressors, trailers, and support vehicles were initially mobilized to the drill site between January 5 and 8, 2010. Alternative drilling tools and construction materials were staged at the Pajarito laydown yard, near the intersection of Pajarito Road and NM 4.

The office trailer, generators, and general field equipment were moved on-site after mobilization of the drilling equipment. Safety barriers and signs were installed around the cuttings containment pit and along the perimeter of the work area. Potable water was obtained from fire hydrant #04-914 near the intersection of Puye and Pajarito Roads, approximately 3.1 mi. from the drill site.

3.0 DRILLING ACTIVITIES

This section describes the drilling strategy and approach and provides a chronological summary of field activities conducted at monitoring well R-52.

3.1 Drilling Approach

The R-52 borehole was drilled using a Schramm T130XD Rotadrill dual-rotary drilling rig with casing rotator. The dual-rotary system allows for advancement of casing with the casing rotator while drilling with conventional air/mist/foam methods with the drill string. The Schramm T130XD drill rig was equipped with conventional 5.5-in.-outside diameter (O.D.) dual-tube drill pipe, tricone bits, downhole hammer bits, and general drilling equipment. Auxiliary equipment included two Ingersoll Rand 1170-ft^3/min trailer-mounted air compressors and three Sullair 1150XHH skid-mounted air compressors. Three sizes of American Society for Testing and Materials (ASTM) A53 grade B flush-welded mild carbon-steel casing were used: 24-in., 18-in., and 12-in. The dual-rotary and standard rotary (open-hole) techniques used filtered compressed air and fluid-assisted air to evacuate cuttings from the borehole. In addition, the casing sizes selected ensured that the required 2-in.-minimum annular thickness of the filter pack around a 5.6-in.-O.D. well, as required by the Consent Order (Section X.C.3), would be met. Cuttings samples were collected at 5-ft intervals in the borehole from 0 to 1175 ft bgs to characterize the lithologies encountered in the borehole.

Potable water and Baroid brand AQF-2 foaming agent were used, as needed, between ground surface and 915 ft bgs (approximately 100 ft above the anticipated top of the regional aquifer). The fluids were used to cool the bit and help lift cuttings from the borehole. Total amounts of drilling fluids introduced into the borehole are presented in Table 3.1-1.

3.2 Chronology of Drilling Activities

The R-52 borehole was drilled between January 9 and February 6, 2010. Drilling began on January 9 at 1021 h. A 24-in. casing was advanced and set at 63.8 ft bgs, and an 18-in. casing was set at 65.0 ft bgs. Between January 11 and 13, 2010, a 17-in. open borehole was advanced from 66.0 ft bgs to 553.0 ft bgs using both a tricone bit and a hammer bit. The hole was overreamed using a 22-in. tricone bit to

560.0 ft bgs, at which time borehole stability issues were encountered, and an 18-in. casing was advanced to this depth.

The 17-in. open borehole was advanced to 737.0 ft bgs between January 16 and 20, 2010. A 15.5-in. bit and an 11.6-in. bit were used to advance the borehole to 955 ft bgs, but ultimately the borehole was overreamed with a 15.5-in. tricone bit to 945.7 ft bgs. Perched water was first observed while drilling at 916.0 ft bgs and was sampled on January 27. AQF-2 drilling foam was discontinued at this depth, approximately 915 ft bgs. The DTW of the perched zone was measured at 708.4 ft bgs on January 28, and again at 701.2 ft bgs on January 31, with the borehole depth at 955.0 ft bgs. Video logging performed by Laboratory personnel on January 31 confirmed the presence of perched water at 701.0 ft bgs.

Following the Laboratory's geophysical logging activities, the borehole was advanced from 945.7 ft bgs to TD of 1175.0 ft bgs using a 14.3-in. under-reamer hammer bit and 12-in. casing advance. Regional water was first observed while drilling at 1054 ft bgs, and after a recovery period of approximately 7 h, it was measured at 1016.3 ft bgs. A screening sample was collected upon first encountering regional groundwater on the morning of February 6. The borehole TD of 1175.0 ft bgs was reached on February 6 at 1500 h; a second groundwater screening sample was collected by airlifting at TD. A final natural gamma log was obtained by Laboratory personnel on February 7, and DTW was tagged at 1020.6 ft bgs.

Drilling was conducted for 24 h/d in two 12-h shifts, 7 d/wk.

4.0 SAMPLING ACTIVITIES

The following sections describe the cuttings and groundwater sampling activities conducted during the drilling and completion of monitoring well R-52. All sampling activities were conducted in accordance with applicable quality procedures (QPs).

4.1 Cuttings Sampling

Cuttings samples were collected from the borehole at 5-ft intervals from ground surface to the TD of 1175.0 ft bgs. Over each interval, approximately 500 mL of bulk cuttings was collected by the site geologist from the discharge cyclone, placed in resealable plastic bags, labeled, and archived in core boxes. Smaller size fractions (>#10 and >#35 mesh) were sieved from the bulk cuttings and placed in chip trays along with unsieved (whole rock) cuttings. Recovery of drill cuttings was excellent with 99% recovery over the borehole interval. Intervals with no recovery included 90 to 95 ft bgs, 740 to 745 ft bgs, and 915 to 920 ft bgs. Radiation control technicians screened cuttings before removal from the site; all screening measurements were within the range of background values. The core boxes and chip trays were delivered to the Laboratory's archive at the conclusion of drilling activities. The borehole lithologic log for R-52 is presented in Appendix A and summarized in section 5.1.

4.2 Water Sampling

One perched-water sample was collected during borehole drilling at a depth of 916.0 ft bgs. The sample was collected on January 27 with a bailer. Perched-zone screening samples were analyzed for metals, cations, anions (including perchlorate), high explosives (HE), volatile organic compounds (VOCs) and low-level tritium (LH3).

An initial regional groundwater screening sample from the top of the regional aquifer was collected by airlifting at 1054 ft bgs on the morning of February 6, 2010. Another screening sample was collected by airlifting from the regional aquifer at borehole TD at the end of the day on February 6, 2010. Regional groundwater samples were analyzed for metals, anions, (including perchlorate), cations, HE, VOCs, and LH3. During well development, three samples were collected from the upper screened interval and analyzed for total organic carbon (TOC); three samples were collected from the lower screened interval and also analyzed for TOC. Additionally, the final samples collected at the end of development for each screen were analyzed for metals, cations, and anions, including perchlorate.

Table 4.2-1 shows a summary of screening samples collected during drilling and development of R-52. Groundwater chemistry and field water quality parameters are discussed in Appendix B.

Further groundwater characterization sampling will be conducted 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 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 report issued by the Laboratory. After the first year, the analytical suite and sample frequency 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 from ground surface to 1175.0 ft bgs at R-52 is presented below.

5.1 Stratigraphy

The stratigraphy for the R-52 borehole is presented below. Lithologic descriptions are based on cuttings samples collected from the discharge cyclone. Cuttings and borehole geophysical and video logs were used to identify geologic contacts. Figure 5.1-1 shows the stratigraphy at R-52. A detailed lithologic log based on analysis of drill cuttings is presented in Appendix A.

Quaternary Alluvium, Qal (0 to 10 ft bgs)

Quaternary alluvium occurred from ground surface to 10 ft bgs. It consisted of fine- to medium-grained alluvial sediments, with moderate to highly weathered, pinkish-gray to light brown, subangular to subrounded fragments and abundant silt in the matrix.

Unit 2, Tshirege Member of the Bandelier Tuff, Qbt 2 (10 to 35 ft bgs)

Unit 2 of the Tshirege Member of the Bandelier Tuff occurred from 10 to 35 ft bgs. Unit 2 consisted of light gray to gray, poorly to moderately welded, crystal rich tuff.

Unit 1v, Tshirege Member of the Bandelier Tuff, Qbt 1v (35 to 140 ft bgs)

Unit 1v of the Tshirege Member of the Bandelier Tuff occurred from 35 to 140 ft bgs. Unit 1v consisted of gray/dark gray to pinkish-gray/dark brown, poorly to nonwelded, crystal rich tuff.

Unit 1g, Tshirege Member of the Bandelier Tuff, Qbt 1g (140 to 225 ft bgs)

Unit 1g of the Tshirege Member of the Bandelier Tuff occurred from 140 to 225 ft bgs. Unit 1g consisted of pinkish-gray to pink, poorly to nonwelded, vitric pumice and tuff.

Cerro Toledo Interval, Qct (225 to 250 ft bgs)

The Cerro Toledo interval occurred from 225 to 250 ft bgs and consisted of very pale brown to pale brown tuffaceous sedimentary deposits separating the Tshirege and Otowi Members of the Bandelier Tuff. The deposits were predominantly reworked tuff with some sands, gravels, and cobbles derived from Tschicoma dacites in the Sierra de los Valles highlands west of the Pajarito Plateau.

Otowi Member of the Bandelier Tuff, Qbo (250 to 530 ft bgs)

The Otowi Member of the Bandelier Tuff occurred from 250 to 530 ft bgs and consisted of a pink/very pale brown to light yellowish-brown/pale brown, glassy, pumiceous, poorly welded ash-flow tuff with lithic clasts and intermediate composition volcanic rocks.

Guaje Pumice Bed of the Otowi Member of the Bandelier Tuff, Qbog (530 to 540 ft bgs)

The Guaje Pumice Bed occurred from 530 to 540 ft bgs. The pumice bed, white to very pale brown, contained abundant pumice fragments (up to 80%) with subordinate amounts of volcanic lithics and quartz and sanidine phenocrysts.

Puye Formation, Tpf (540 to 550 ft bgs)

The Puye Formation occurred from 540 to 550 ft bgs. The formation consisted of white to very pale brown/dark gray volcaniclastic sediments, with well-graded subangular to subrounded gravels, sands, and silts.

Cerros del Rio volcanic rocks, Tb 4 (550 to 925 ft bgs)

The Cerros del Rio volcanic rocks occurred from 550 to 925 ft bgs and consisted of aphanitic to porphyritic, nonvesicular to slightly vesicular basalt and basaltic scoria containing phenocrysts (predominantly olivine). Fragments were medium-dark gray to dark gray basalts, orange to red clay, lithic fragments, and trace quartz and sanidine crystals.

Puye Formation, Tpf (925 to 1175.0 ft bgs)

The Puye Formation occurred from 925 to borehole TD at 1175.0 ft bgs. In this interval, the Puye Formation consisted of lacustrine sedimentary deposits from 925 to 980 ft bgs and volcaniclastic sediments from 980 to 1175.0 ft bgs. The lacustrine deposits ranged from gray to very dark gray, silt and silty clay with pumice fragments. The lower portion consisted of poorly to well-sorted gravels with angular to subrounded sands, silts, and clays containing up to 100% porphyritic to aphyric intermediate volcanics.

5.2 Groundwater

One perched-water zone was expected based on the occurrence of perched water during drilling of well R-37, approximately 0.2 mi east-southeast of R-52 (Figure 1.0-1). The perched zone was projected at approximately 910 ft bgs, at the base of the Cerros del Rio volcanic rocks. On January 27, 2010, borehole advancement was temporarily suspended at 916 ft bgs. The hole was blown out for 38 min and allowed to recover for 20 min before a screening sample was collected at 916 ft bgs. After drilling to 955 ft bgs, tools were tripped out of the borehole the following day, and DTW was tagged at 708.4 ft bgs. On January 31, 2010, DTW was tagged at 701.2 ft bgs and measured at 701.0 ft bgs on the Laboratory video log. Several notable fractures were observed within the Cerros del Rio volcanic rocks at approximately 690 ft bgs.

Regional groundwater was expected at approximately 1021 ft bgs within the Puye Formation. On February 5, 2010, regional groundwater was first detected during drilling at 1054 ft bgs; borehole advancement was temporarily suspended, and the hole was blown out for 28 min. After a recovery period of approximately 7 h, the DTW was consistently tagged at 1016.3 ft bgs on three consecutive occasions on February 5, 2010. On April 20, following well development but before aquifer testing began, the composite DTW was recorded at 1018.0 ft bgs.

During the aquifer test of the lower screened interval (1107.0 to 1117.0 ft bgs), flow rates of approximately 8 gallons per minute (gpm) were maintained, and flow rates of approximately 4 gpm were maintained during the aquifer test conducted in the upper screened interval (1035.2 to 1055.7 ft bgs).

Groundwater screening samples collected during drilling and well development are discussed in Section 4.2. Groundwater chemistry and field water-quality parameters are discussed in Appendix B. Aquifer testing data and analysis are discussed in Appendix E.

6.0 BOREHOLE LOGGING

During the course of drilling and well construction activities, video, geophysical, and caliper logging were conducted to evaluate borehole conditions. Video and geophysical logging results are summarized in Table 6.0-1.

6.1 Video Logging

Laboratory personnel conducted video logging on January 31, March 12, and March 19, 2010. On January 31, 2010, Laboratory personnel ran a video log that confirmed the bottom of the 18-in. casing was at 560.0 ft bgs. Additionally, the depth to perched water was observed at 701.0 ft bgs, and several notable fractures were observed within the Cerros del Rio volcanic rocks from 608 to 690 ft bgs. On March 12, 2010, Laboratory personnel ran a video log to inspect the hole and attempt to find casing bottom; however, cloudy water obscured visibility below 1130.0 ft bgs. On March 19, 2010, Laboratory personnel ran a video log to determine if the third attempt at cutting the 12-in. steel casing was successful and confirmed that it was cut at 1125.3 ft bgs. Details of these logs are provided in Table 6.0-1 and included in Appendix C.

6.2 Geophysical Logging

On January 31, 2010, Laboratory personnel ran natural gamma and induction logs of the R-52 borehole to 941.4 and 9404 ft bgs, respectively. On February 7, 2010, Laboratory personnel conducted natural gamma logging of the R-52 borehole to 1172.9 ft bgs. On March 6, 2010, Laboratory personnel attempted to conduct a natural gamma log of the borehole to determine if the second attempt to cut the casing was successful, but results were inconclusive. However, the natural gamma log did determine that the bottom of the 18-in. steel casing was at 572.0 ft bgs, after being dropped on March 3, 2010. On March 12, 2010, Laboratory personnel ran a caliper tool downhole to inspect the hole and attempt to find casing bottom, with results indicating that the casing was not cut. On March 20, 2010, Jet West personnel ran a caliper tool downhole to confirm that the casing was cut, with results indicating that the casing was successfully cut at 1125.3 ft bgs. Details of these logs are provided in Table 6.0-1. The geophysical logs are included in Appendix D.

7.0 WELL INSTALLATION

The R-52 well was installed between March 21 and April 5, 2010. The following sections describe the well design and well construction activities.

7.1 Well Design

The R-52 well was designed in general accordance with the NMED-approved drilling work plan (LANL 2009, 107685). NMED approved the final well design before installation. Appendix F contains the R-52 proposed final well design report and NMED approval. The well was designed with dual screens to monitor regional aquifer groundwater quality in the Puye Formation. The 20-ft-long upper screen was installed from 1035.2 to 1055.7 ft bgs, and the 10-ft-long lower screen was installed from 1107.0 to 1117.0 ft bgs with a 10.0-ft stainless-steel sump below the bottom of the lower screen.

7.2 Well Construction

The R-52 monitoring well was constructed of 5.0-in.-inside diameter (I.D.)/5.6-in.-O.D., type A304 passivated stainless-steel threaded casing fabricated to ASTM A312 standards. The screened intervals included one 20-ft upper screen and one 10-ft lower screen of 5.0-in.-I.D. rod-based 0.020-in. wire-wrapped well screen. Compatible external stainless-steel couplings (also type A304 stainless steel fabricated to ASTM A312 standards) were used to join all individual casing and screen sections. The stainless-steel well casing and screen were provided by the Laboratory, and all casing and screens were steam-pressure washed on-site before installation. A 2-in.-I.D. threaded steel tremie pipe (decontaminated before use) was used to deliver annular backfill materials downhole during well construction (Table 7.2-1). The Schramm T130XD rig used to drill the borehole to TD was also used for well construction activities.

The well was constructed with two screened intervals as specified in the well design. Stainless steel centralizers (four sets of four) were welded to the well casing at 1034.0 and 1057.0 ft bgs above and below the upper screen, and at 1104.0 and 1119.0 ft bgs above and below the lower screen. Figure 7.2-1 shows the as-built well construction diagram for R-52.

Between February 6 and 7, 2010, the 5.6-in.-O.D. stainless-steel well casing was moved on-site and decontaminated. Anticipated quantities of backfill materials were also mobilized to the drill site during this time. On March 21, 2010, general preparations were made to begin well construction, and the tremie pipe was tripped into the borehole.

On February 7, immediately before well installation, the drill crew attempted to cut the 12-in. casing shoe, and Laboratory personnel ran downhole borehole geophysics. An initial attempt was made on February 11 to pull the 12-in. drill casing and begin backfilling with bentonite; however, it could not be retracted. The drill casing either had not been successfully cut or was stuck downhole. From February 12 to March 19, 2010, after the well casing and screen had been removed from the borehole, the 12-in. casing was cut a second time, and the well casing and screen were again installed. Multiple unsuccessful attempts were made to retract the 12-in. drill casing from the borehole. During this time, on March 3, 2010, a 559.5-ft length of 18-in. casing was dropped and landed from 12.5 to 572.0 ft bgs. On March 19 and 20, 2010, after again removing the well casing and screen from the borehole, a third successful attempt was made to cut the 12-in. casing with a Weatherford cutting tool. A Laboratory video log run on March 19 and Jet West caliper log run on March 20 confirmed that the casing had been cut at 1125.3 ft bgs. A 47.9-ft-long section of 12-in. casing was left in the borehole from 1125.3 to 1173.2 ft bgs.

The well casing and screen were installed on March 21 and 22, followed by emplacement of annular materials from March 23 to April 5, 2010. Each casing joint was threaded to the string using ASTM A312 standard stainless-steel couplings. On March 22, the well casing was installed in the borehole with the bottom of the casing at a depth of 1128.7 ft bgs. On March 23, the borehole depth was tagged at 1160.1 ft bgs, indicating 14.9 ft of formational slough was present in the bottom of the borehole.

Annular bentonite backfill was placed around the well casing sump from 1160.1 to 1123.9 ft bgs. This bottom seal consisted of 0.375-in. bentonite chips with a volume of 31.3 ft^3. The primary filter pack for the lower screen consisted of 33.0 ft^3 of 10/20 clean silica sand from 1123.9 to 1101.1 ft bgs. Swabbing was conducted multiple times above and just below the screen to promote proper settling of the filter pack sand. The fine-sand transition collar (2.0 ft^3 of 20/40 clean silica sand) was placed from 1101.1 to 1099.0 ft bgs. All quantities of backfill materials at this point were within 20% of calculated volumes, with the exception of the primary filter pack, which used a volume that was 35% more than calculated (Figure 7.2-1). The primary filter pack for the lower screen was set within the volcaniclastic sediments portion of the Puye Formation, a poorly consolidated sedimentary deposit that has a tendency to washout and form voids during drilling and hence contains intervals that require larger volumes of backfill material during well construction.

A bentonite seal was placed above the lower screen sand pack from 1099.0 to 1061.7 ft bgs, 6.0 ft below the upper screen. This interscreen seal consisted of 64.2 ft^3 of 0.375-in. bentonite chips. The actual volume used was 45% more than calculated (35.5 ft^3). It is likely that the borehole had also washed out across the unconsolidated Puye Formation in this interval, creating a larger than anticipated borehole diameter.

The primary 10/20 clean silica sand filter pack was placed around the upper screened interval from 1061.7 to 1029.5 ft bgs. Backfilling of this zone required 9% more material than calculated (30.6 ft^3 calculated, 33.5 ft^3 used). Swabbing was again conducted multiple times above and just below the screen to promote proper settling of the sand pack before installation of the 20/40 clean silica fine-sand transition collar from 1029.5 to 1028.3 ft bgs. Backfilling of this zone, also in the Puye Formation volcaniclastic sediments, required 70% more material than calculated (1.2 ft^3 calculated, 4.0 ft^3 used), likely because of borehole washouts.

A bentonite seal was placed above the transition sand from 1028.3 to 579.3 ft bgs. The seal consisted of 0.375-in. bentonite chips. The quantity of materials used in this zone was 507.2 ft^3, about 6% less than the calculated volume of 536.6 ft^3.

Earlier in the drilling of R-52, on March 3, approximately 559.5 ft of 18-in. steel casing was lost downhole. The Laboratory natural gamma log on March 6, 2010, showed the casing was present from 12.5 to 572.0 ft bgs. A neat cement grout seal was pumped inside the bottom of the 18-in. casing and in the annular space between the casing and the borehole wall from 579.3 to 565.9 ft bgs within the Cerros del Rio volcanic rocks. The volume of cement used was 30.0 ft^3, about 50% more than the calculated volume of 20.1 ft^3. This zone of highly weathered basalt (see description in Appendix A) likely contains fractures that may account for the larger volume of neat cement required.

The remainder of the upper bentonite seal of 0.375-in. bentonite chips was placed from to 565.9 to 74.4 ft bgs inside of the 18-in. casing and in the annular space between the casing and the borehole wall. The actual volume used was 1280.5 ft^3, about 9% more than the calculated volume of 1169.1 ft^3.

The final surface seal of 100 weight percent (wt%) Portland cement was pumped from 74.4 ft bgs to 3 ft bgs inside the 18-in. casing and in the annular space between the casing and the borehole wall. The difference between the actual volume used (183.6 ft^3) and the calculated volume (193.1 ft^3) was about

5%. Completion of the grout seal to surface marked R-52 regional monitoring well completion per NMED standards at 2230 h on April 5, 2010.

8.0 POSTINSTALLATION ACTIVITIES

Following well installation, the screened intervals were developed and tested, the wellhead was completed, the sampling system was installed, and a geodetic survey was conducted.

8.1 Well Development

Well development of the screened intervals was performed independently and was completed using the Semco 115000 pulling unit. Well development of the lower screened interval occurred between April 8 and April 19, 2010. Well development of the upper screened interval occurred between April 9 and 10 and April 26 and 28, 2010.

Well development of each screened interval began with bailing water and swabbing near the screen, which helped to remove formational fines from around the filter pack and sump. The swabbing tool used was a 4.5-in.-diameter, 1-in.-thick rubber disc attached to a weighted-steel rod. The swabbing tool was lowered by wireline and drawn repeatedly in both directions across the screened intervals. Bailing and swabbing continued until the water clarity visibly improved. Upon completion of bailing and swabbing, well development continued using a 10-horse power (hp), 4-in.-diameter Grundfos submersible pump. In total, 32,338 gal. of groundwater were removed from R-52 during well development: 241 gal. of composite water from both screens, 22,698 gal. from the lower screen, and 9399 gal. from the upper screen.

8.1.1 Well Development Field Parameters

Field parameters of turbidity, temperature, potential of hydrogen (pH), dissolved oxygen (DO), oxidation-reduction potential (ORP), and specific conductance were monitored at R-52 during the pumping stage of well development at each screened interval. A flow-through cell was used to measure field parameters during well development. In addition, water samples were collected for TOC analyses from both screens. TOC should be less than 2.0 ppm, and turbidity should be less than 5 nephelometric turbidity units (NTU) to indicate the well has been developed adequately.

Lower Screen

The pH values recorded during well development of the lower screen varied from 5.2 to 12.2 NTU; the large variations indicate that the meter was malfunctioning and, therefore, the pH values less than 6.5 and greater than 8.5 are not accurate. However, during the aquifer testing conducted between April 21 and 23, 2010, pH ranged from 7.6 to 8.1, with a final reading of 7.9.

Temperature of groundwater from the lower screen varied from 18.9 to 20.5°C during well development. DO varied from 1.1 to 3.2 mg/L, and specific conductance ranged from 108 to 146 microsiemens per centimeter (µS/cm). Corrected oxidation-reduction potential (Eh) values ranged from 154.5 to 209.6 millivolt (mV) during well development.

Turbidity values ranged from 0.2 to 117 NTU over the course of well development of the lower screen, with a high reading of 2753.0 NTU measured during swabbing and bailing. Approximately half of the turbidity readings recorded during development were 0.0 NTU, suggesting the meter was not functioning correctly on the final day and a half of well development on April 18 and 19. However, during the aquifer testing conducted between April 21 and 23, 2010, turbidity readings ranged from 0.8 to 6.3 NTU, with a final reading of 1.9 NTU. During a final short 5-h period of pumping on May 5, turbidity varied from 49.4 NTU at the beginning to 6.1 NTU at the end. Final accurate field parameter measurements at the end of development for the lower screen were a temperature of 20.0°C and specific conductance of 108 µS/cm. The final TOC concentration was 0.2 mg/L. Table B-1.2-1 presents field parameters and discharge volumes recorded during development.

Upper Screen

During development of the upper screen, measurements of pH varied from 7.9 to 8.5, temperature varied from 14.3 to 22.3°C, DO varied from 1.0 to 4.5 mg/L, and specific conductance varied from 118 to 146 µS/cm. Corrected Eh values ranged from a high of 320.3 mV at the beginning of well development and declined to 251.2 mV near the end. Turbidity ranged from 23.8 NTU at the beginning of development to 0.2 NTU near the end.

Final field parameter measurements at the end of development for the upper screen were as follows: pH was 8.0, temperature was 21.9°C, specific conductance was 137 µS/cm, and turbidity was 0.2 NTU. The final TOC concentration was 0.3 mg/L.

8.2 Aquifer Testing

Aquifer pumping tests of R-52 were conducted by David Schafer and Associates between April 21 and 23, with an additional day of pumping on May 4, 2010, for the lower screen, and between April 30 and May 2 for the upper screen. Several short-duration pumping intervals with short-duration recovery intervals were performed to determine the optimal pumping rate for the 24-h aquifer tests. A 10-hp, 4-in.-diameter Grundfos submersible pump was used to perform the aquifer tests. The lower screen was pumped at a rate of 8 gpm while the upper screen was pumped at 4 gpm. A total of 23,483 gal. of groundwater was purged during aquifer testing activities, 18,864 gal. for the lower screen and 4619 gal. for the upper screen. Field parameters and purge volumes recorded during aquifer testing are shown in Table B-1.2-1. Aquifer test results are presented in Appendix E.

8.3 Dedicated Sampling System Installation

The dedicated sampling system for R-52 was installed between July 16 and 19, 2010. The system is a Baski, Inc..–manufactured system that uses a single 3.0-hp, 4-in.-O.D. environmentally retrofitted Grundfos submersible pump capable of purging each screen interval discretely using pneumatically actuated access port valves. The system includes a viton-wrapped isolation packer between the screen intervals. The pump riser pipe consists of threaded and coupled nonannealed 1-in.-I.D. stainless steel. Two 1-in.-I.D. schedule 80 polyvinyl chloride (PVC) tubes are installed along with and banded to the pump riser for dedicated transducers. The PVC transducer tube for the upper screen is equipped with a 0.010-in. slotted screen with a threaded end cap at the bottom of the tube. The PVC transducer tube for the lower screen is equipped with a flexible nylon tube that extends from a threaded end cap at the bottom of the PVC tube through the isolation packer. Two In-Situ Level Troll 500 transducers were installed in the PVC tubes to monitor water levels in each screened interval.

Sampling system details for R-52 are presented in Figure 8.3-1a. Figure 8.3-1b presents technical notes for the well.

8.4 Wellhead Completion

A reinforced concrete pad, 10 ft ×10 ft × 6.0 in. thick, was installed at the R-52 wellhead. The pad was slightly elevated above ground surface and crowned to promote runoff. The pad will provide long-term structural integrity for the well. A brass monument marker imprinted with well identification information was embedded in the northwest corner of the pad. A 16-in.-O.D. steel protective casing was installed around the well casing to a depth of 3.0 ft bgs and cemented in place. The protective casing was covered with a mushroom cap with locking bar. A 0.5-in. weep hole was drilled near the base of the protective casing to prevent water accumulation inside the protective casing. A total of four removable bollards, painted bright yellow for visibility, were set approximately 1 ft from each of the pad edges to protect the well from accidental vehicle damage. Details of the wellhead completion are presented in Figure 8.3-1a, and technical notes for R-52 are shown in Figure 8.3-1b.

8.5 Geodetic Survey

A geodetic survey of the wellhead components was conducted by a New Mexico licensed professional land surveyor on June 4, 2010, and the data conform to Laboratory Information Architecture project standards IA-CB02, “GIS Horizontal Spatial Reference System,” and IA-D802, “Geospatial Positioning Accuracy Standards for A/E/C and Facility Management.” All coordinates are expressed relative to New Mexico State Plane Coordinate System Central Zone 83 (North American Datum [NAD] 83); elevation is expressed in feet above mean sea level (amsl) using the National Geodetic Vertical Datum of 1929. Survey points included ground-surface elevation near the concrete pad, the top of the brass monument in the concrete pad, the top of the well casing, and the top of the protective casing. The survey data are provided in Table 8.5-1, and the location survey report is provided as Appendix G.

8.6 Waste Management and Site Restoration

Waste generated from the R-52 project includes drilling fluids, purged groundwater, drill cuttings, decontamination water, and contact waste. A summary of the waste characterization samples collected from R-52 is presented in Table 8.6-1.

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

Cuttings produced during drilling are anticipated to be land-applied after a review of associated analytical results per the WCSF and ENV-RCRA-QP-011.1, Land Application of Drill Cuttings. If the drill cuttings do not meet the criterion for land application, they will be disposed of at an authorized facility. Decontamination fluid used for cleaning the drill rig and equipment is currently 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 in accordance with the WCSF and applicable ENV-RCRA procedures. Additionally, the polyethylene liner and containment berms will be removed, and the containment area will be backfilled and regraded, as appropriate.

9.0 DEVIATIONS FROM PLANNED ACTIVITIES

Drilling and sampling at R-52 were performed as specified in the “Well R-52 Drill Plan, Installation of Well R-52, TA-54, Los Alamos National Laboratory, Revision 1” (North Wind Inc. 2009, 109445). Well construction, however, did deviate from the initial Laboratory-approved well design because of difficulty retracting the 12-in. casing from the borehole. The final modified well design was approved by NMED (see Appendix F). In addition, two sections of casing were left in the borehole: a 47.9-ft-long section of 12-in. casing from 1125.3 to 1173.2 ft bgs and a 559.5-ft-long section of 18-in. casing from 12.5 to 572.0 ft bgs.

10.0 ACKNOWLEDGMENTS

Layne Christensen drilled the R-52 borehole and installed the well.

Jet West performed a caliper log of the borehole.

David Schafer and Associates performed the aquifer testing, and David Schafer authored Appendix E, Aquifer Testing Report.

North Wind, Inc., provided oversight of 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. The information is also included in text citations. ER IDs are assigned by the EP Directorate’s RPF and are used to locate the document at the RPF and, where applicable, in the master reference set.

Copies of the master reference set are maintained at the NMED Hazardous Waste Bureau and the 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), October 4, 2007. “Integrated Work Document for Regional and Intermediate Aquifer Well Drilling (Mobilization, Site Preparation and Setup Stages),” Los Alamos National Laboratory, Los Alamos, New Mexico. (LANL 2007, 100972)

LANL (Los Alamos National Laboratory), October 27, 2009. “Waste Characterization Strategy Form for TA-54 Wells R-51 (Well D) and R-52 (Well A) Regional Well Installation and Corehole Drilling,” Los Alamos, New Mexico. (LANL 2009, 107439)

LANL (Los Alamos National Laboratory), December 2009. “Drilling Work Plan for Regional Aquifer Well R-52,” Los Alamos National Laboratory document LA-UR-09-7264, Los Alamos, New Mexico. (LANL 2009, 107685)

North Wind Inc., December 18, 2009. “Well R-52 Drill Plan, Installation of Well R-52, TA-54, Los Alamos National Laboratory, Revision 1,” plan prepared for Los Alamos National Laboratory, Los Alamos, New Mexico. (North Wind, Inc., 2009, 109445)

11.2 Map Data Sources

Coarse Scale Drainage Arcs; Los Alamos National Laboratory, Water Quality and Hydrology Group of the Risk Reduction and Environmental Stewardship Program; as published 03 June 2003.

Dirt Road Arcs; Los Alamos National Laboratory, KSL Site Support Services, Planning, Locating and Mapping Section; 19 March 2008; as published 04 January 2008.

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

Materials Disposal Area; Los Alamos National Laboratory, RRES Remediation Services Project, ER2004-0221; 1:2,500 Scale Data; 25 April 2004.

Paved Road Arcs; Los Alamos National Laboratory, KSL Site Support Services, Planning, Locating and Mapping Section; 19 March 2008; as published 04 January 2008.

Penetrations; Los Alamos National Laboratory, Environment and Remediation Support Services, ER2006-0664; 1:2,500 Scale Data, 01 July 2006.

Structures; Los Alamos National Laboratory, KSL Site Support Services, Planning, Locating and Mapping Section; 19 March 2008; as published 04 January 2008

Technical Area Boundaries; Los Alamos National Laboratory, Site Planning and Project Initiation Group, Infrastructure Planning Division; 19 September 2007.

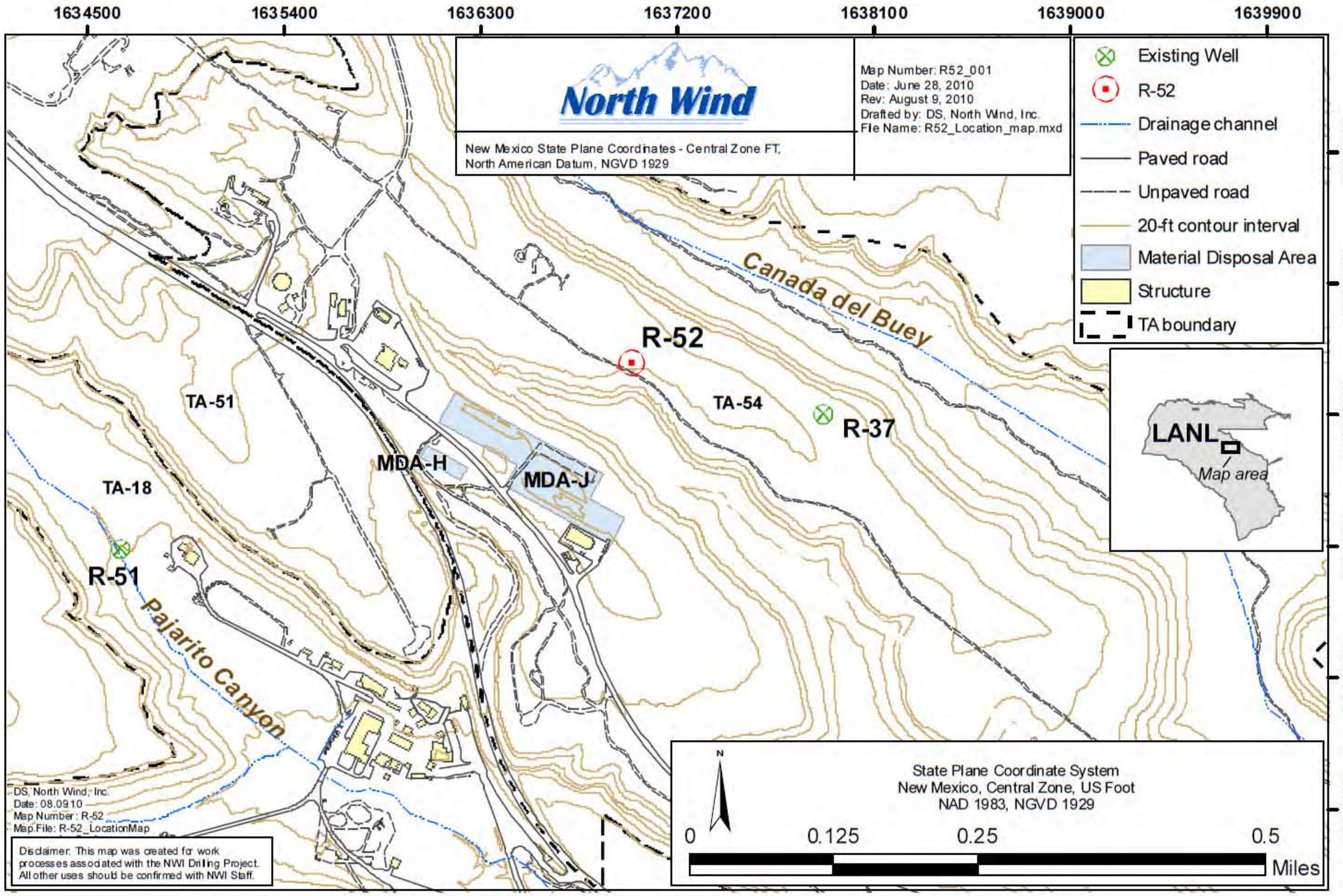
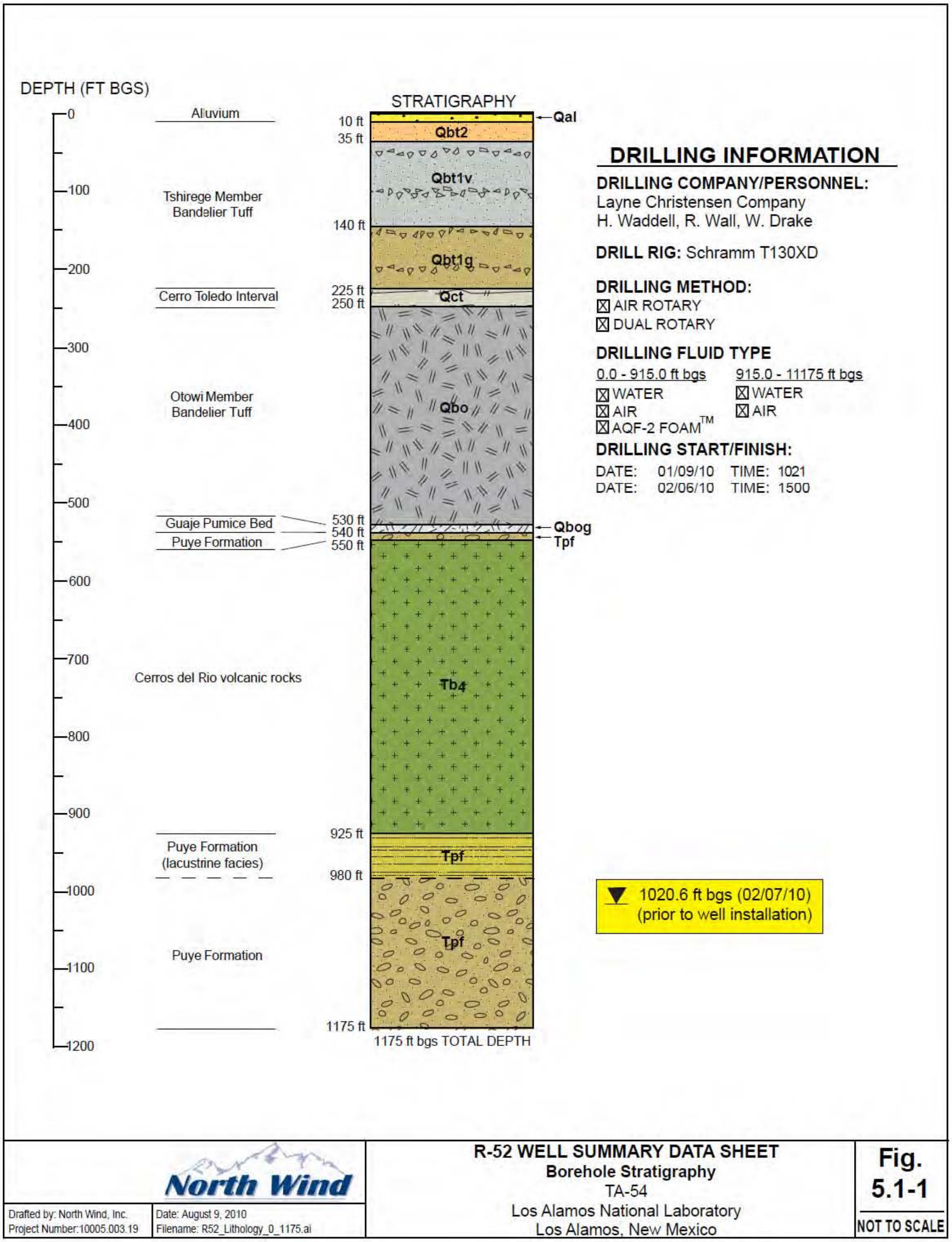


Figure 1.0-1 Regional aquifer well R-52 location



DRILLING INFORMATION

DRILLING COMPANY/PERSONNEL:
Layne Christensen Company
H. Waddell, R. Wall, W. Drake

DRILL RIG: Schramm T130XD

DRILLING METHOD:
☒ AIR ROTARY
☒ DUAL ROTARY

DRILLING FLUID TYPE

0.0 - 915.0 ft bgs	915.0 - 11175 ft bgs
☒ WATER	☒ WATER
☒ AIR	☒ AIR
☒ AQF-2 FOAM™	

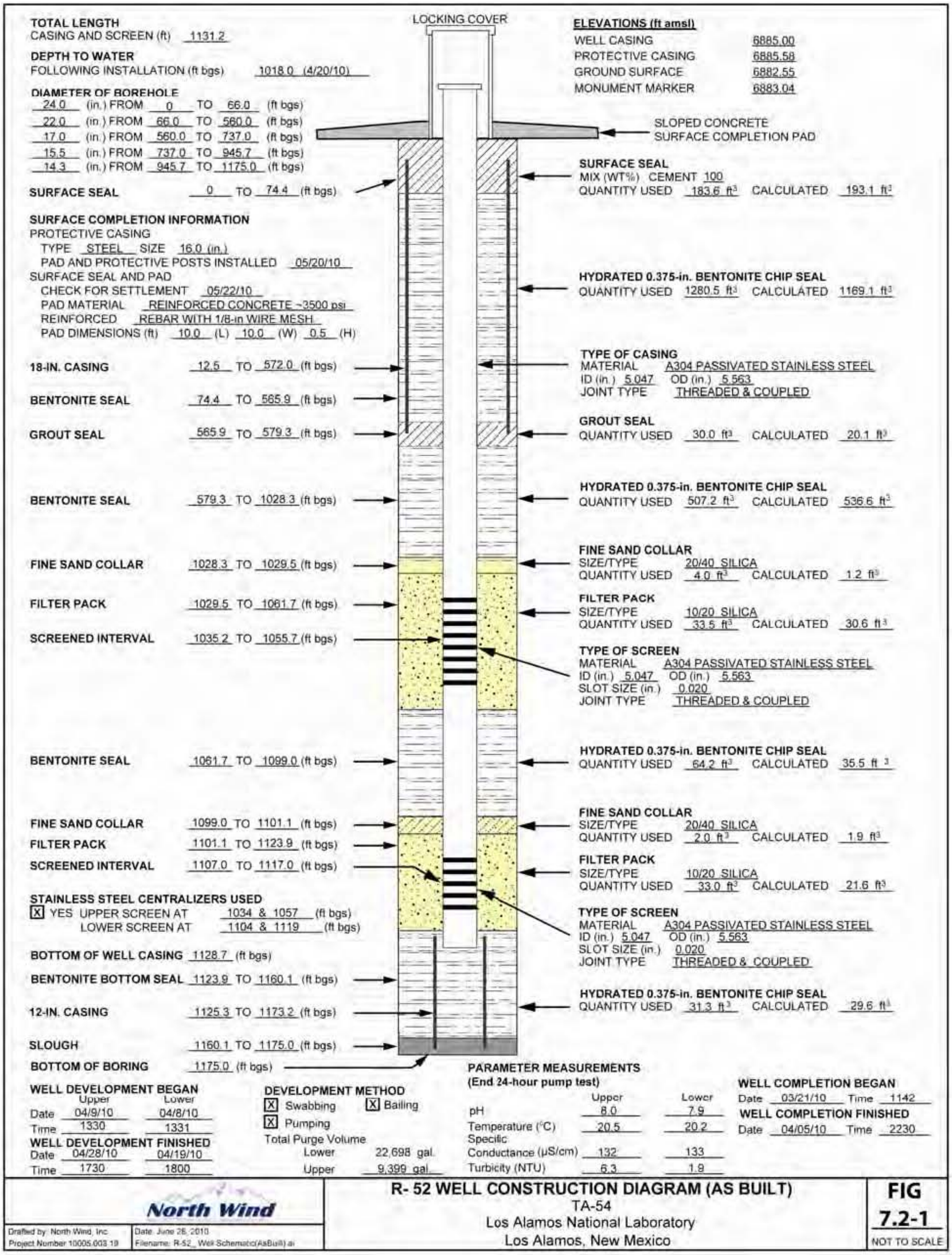
DRILLING START/FINISH:
DATE: 01/09/10 TIME: 1021
DATE: 02/06/10 TIME: 1500

Drafted by: North Wind, Inc.
Project Number:10005.003.19
Date: August 9, 2010
Filename: R52_Lithology_0_1175.ai

R-52 WELL SUMMARY DATA SHEET
Borehole Stratigraphy
TA-54
Los Alamos National Laboratory
Los Alamos, New Mexico

Fig. 5.1-1
NOT TO SCALE

Figure 5.1-1 R-52 borehole stratigraphy



TOTAL LENGTH
CASING AND SCREEN (ft) 1131.2

DEPTH TO WATER
FOLLOWING INSTALLATION (ft bgs) 1018.0 (4/20/10)

DIAMETER OF BOREHOLE
24.0 (in.) FROM 0 TO 66.0 (ft bgs)
22.0 (in.) FROM 66.0 TO 560.0 (ft bgs)
17.0 (in.) FROM 560.0 TO 737.0 (ft bgs)
15.5 (in.) FROM 737.0 TO 945.7 (ft bgs)
14.3 (in.) FROM 945.7 TO 1175.0 (ft bgs)

SURFACE SEAL 0 TO 74.4 (ft bgs)

SURFACE COMPLETION INFORMATION
PROTECTIVE CASING
TYPE STEEL SIZE 16.0 (in.)
PAD AND PROTECTIVE POSTS INSTALLED 05/20/10
SURFACE SEAL AND PAD
CHECK FOR SETTLEMENT 05/22/10
PAD MATERIAL REINFORCED CONCRETE ~3500 psi
REINFORCED REBAR WITH 1/8-in WIRE MESH
PAD DIMENSIONS (ft) 10.0 (L) 10.0 (W) 0.5 (H)

18-IN. CASING 12.5 TO 572.0 (ft bgs)

BENTONITE SEAL 74.4 TO 565.9 (ft bgs)

GROUT SEAL 565.9 TO 579.3 (ft bgs)

BENTONITE SEAL 579.3 TO 1028.3 (ft bgs)

FINE SAND COLLAR 1028.3 TO 1029.5 (ft bgs)

FILTER PACK 1029.5 TO 1061.7 (ft bgs)

SCREENED INTERVAL 1035.2 TO 1055.7 (ft bgs)

BENTONITE SEAL 1061.7 TO 1099.0 (ft bgs)

FINE SAND COLLAR 1099.0 TO 1101.1 (ft bgs)

FILTER PACK 1101.1 TO 1123.9 (ft bgs)

SCREENED INTERVAL 1107.0 TO 1117.0 (ft bgs)

STAINLESS STEEL CENTRALIZERS USED
☒ YES UPPER SCREEN AT 1034 & 1057 (ft bgs)
LOWER SCREEN AT 1104 & 1119 (ft bgs)

BOTTOM OF WELL CASING 1128.7 (ft bgs)

BENTONITE BOTTOM SEAL 1123.9 TO 1160.1 (ft bgs)

12-IN. CASING 1125.3 TO 1173.2 (ft bgs)

SLOUGH 1160.1 TO 1175.0 (ft bgs)

BOTTOM OF BORING 1175.0 (ft bgs)

ELEVATIONS (ft amsl)

WELL CASING	6885.00
PROTECTIVE CASING	6885.58
GROUND SURFACE	6882.55
MONUMENT MARKER	6883.04

SURFACE SEAL
MIX (WT%) CEMENT 100
QUANTITY USED 183.6 ft³ CALCULATED 193.1 ft³

HYDRATED 0.375-in. BENTONITE CHIP SEAL
QUANTITY USED 1280.5 ft³ CALCULATED 1169.1 ft³

TYPE OF CASING
MATERIAL A304 PASSIVATED STAINLESS STEEL
ID (in.) 5.047 OD (in.) 5.563
JOINT TYPE THREADED & COUPLED

GROUT SEAL
QUANTITY USED 30.0 ft³ CALCULATED 20.1 ft³

HYDRATED 0.375-in. BENTONITE CHIP SEAL
QUANTITY USED 507.2 ft³ CALCULATED 536.6 ft³

FINE SAND COLLAR
SIZE/TYPE 20/40 SILICA
QUANTITY USED 4.0 ft³ CALCULATED 1.2 ft³

FILTER PACK
SIZE/TYPE 10/20 SILICA
QUANTITY USED 33.5 ft³ CALCULATED 30.6 ft³

TYPE OF SCREEN
MATERIAL A304 PASSIVATED STAINLESS STEEL
ID (in.) 5.047 OD (in.) 5.563
SLOT SIZE (in.) 0.020
JOINT TYPE THREADED & COUPLED

HYDRATED 0.375-in. BENTONITE CHIP SEAL
QUANTITY USED 64.2 ft³ CALCULATED 35.5 ft ³

FINE SAND COLLAR
SIZE/TYPE 20/40 SILICA
QUANTITY USED 2.0 ft³ CALCULATED 1.9 ft³

FILTER PACK
SIZE/TYPE 10/20 SILICA
QUANTITY USED 33.0 ft³ CALCULATED 21.6 ft³

TYPE OF SCREEN
MATERIAL A304 PASSIVATED STAINLESS STEEL
ID (in.) 5.047 OD (in.) 5.563
SLOT SIZE (in.) 0.020
JOINT TYPE THREADED & COUPLED

HYDRATED 0.375-in. BENTONITE CHIP SEAL
QUANTITY USED 31.3 ft³ CALCULATED 29.6 ft³

WELL DEVELOPMENT BEGAN

	Upper	Lower
Date	04/9/10	04/8/10
Time	1330	1331

WELL DEVELOPMENT FINISHED

Date	04/28/10	04/19/10
Time	1730	1800

DEVELOPMENT METHOD
☒ Swabbing ☒ Bailing
☒ Pumping
Total Purge Volume
Lower 22,698 gal.
Upper 9,399 gal.

PARAMETER MEASUREMENTS
(End 24-hour pump test)

	Upper	Lower
pH	8.0	7.9
Temperature (°C)	20.5	20.2
Specific Conductance (µS/cm)	132	133
Turbicity (NTU)	6.3	1.9

WELL COMPLETION BEGAN
Date 03/21/10 Time 1142
WELL COMPLETION FINISHED
Date 04/05/10 Time 2230

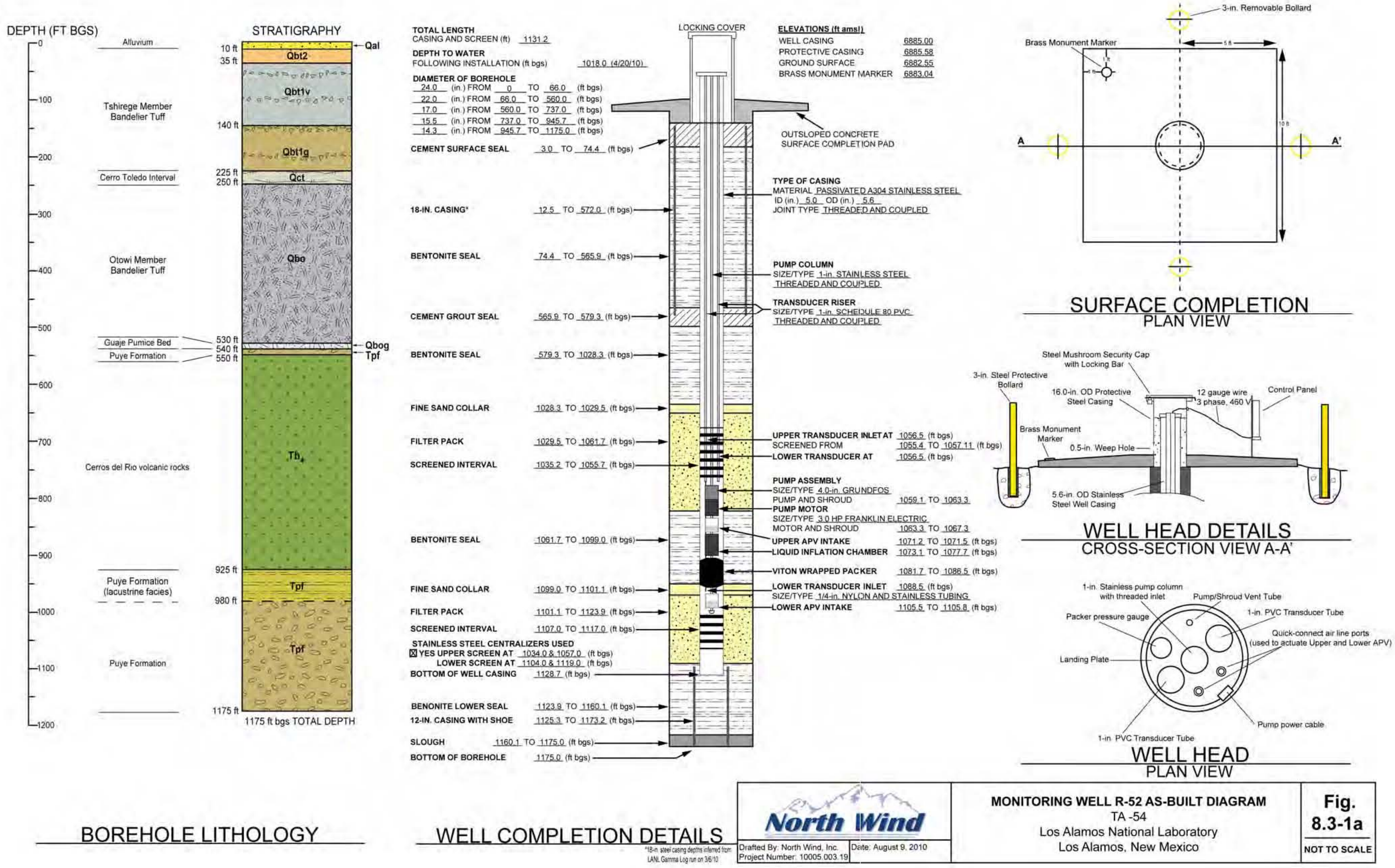
North Wind

Drafted by: North Wind, Inc.
Project Number 10005.003.19
Date: June 28, 2010
Filename: R-52_ Well Schematic(AsBuilt).ai

R- 52 WELL CONSTRUCTION DIAGRAM (AS BUILT)
TA-54
Los Alamos National Laboratory
Los Alamos, New Mexico

FIG 7.2-1
NOT TO SCALE

Figure 7.2-1 R-52 as-built well construction diagram



TOTAL LENGTH
CASING AND SCREEN (ft) 1131.2

DEPTH TO WATER
FOLLOWING INSTALLATION (ft bgs) 1018.0 (4/20/10)

DIAMETER OF BOREHOLE
24.0 (in.) FROM 0 TO 66.0 (ft bgs)
22.0 (in.) FROM 66.0 TO 560.0 (ft bgs)
17.0 (in.) FROM 560.0 TO 737.0 (ft bgs)
15.5 (in.) FROM 737.0 TO 945.7 (ft bgs)
14.3 (in.) FROM 945.7 TO 1175.0 (ft bgs)

CEMENT SURFACE SEAL 3.0 TO 74.4 (ft bgs)
18-IN. CASING* 12.5 TO 572.0 (ft bgs)
BENTONITE SEAL 74.4 TO 565.9 (ft bgs)
CEMENT GROUT SEAL 565.9 TO 579.3 (ft bgs)
BENTONITE SEAL 579.3 TO 1028.3 (ft bgs)
FINE SAND COLLAR 1028.3 TO 1029.5 (ft bgs)
FILTER PACK 1029.5 TO 1061.7 (ft bgs)
SCREENED INTERVAL 1035.2 TO 1055.7 (ft bgs)
BENTONITE SEAL 1061.7 TO 1099.0 (ft bgs)
FINE SAND COLLAR 1099.0 TO 1101.1 (ft bgs)
FILTER PACK 1101.1 TO 1123.9 (ft bgs)
SCREENED INTERVAL 1107.0 TO 1117.0 (ft bgs)

STAINLESS STEEL CENTRALIZERS USED
☒ **YES UPPER SCREEN AT** 1034.0 & 1057.0 (ft bgs)
LOWER SCREEN AT 1104.0 & 1119.0 (ft bgs)
BOTTOM OF WELL CASING 1128.7 (ft bgs)

BENONITE LOWER SEAL 1123.9 TO 1160.1 (ft bgs)
12-IN. CASING WITH SHOE 1125.3 TO 1173.2 (ft bgs)
SLOUGH 1160.1 TO 1175.0 (ft bgs)
BOTTOM OF BOREHOLE 1175.0 (ft bgs)

*18-in. steel casing depths inferred from LANL Gamma Log run on 3/6/10

ELEVATIONS (ft amsl)
WELL CASING 6885.00
PROTECTIVE CASING 6885.58
GROUND SURFACE 6882.55
BRASS MONUMENT MARKER 6883.04

TYPE OF CASING
MATERIAL PASSIVATED A304 STAINLESS STEEL
ID (in.) 5.0 OD (in.) 5.6
JOINT TYPE THREADED AND COUPLED

PUMP COLUMN
SIZE/TYPE 1-in. STAINLESS STEEL THREADED AND COUPLED

TRANSDUCER RISER
SIZE/TYPE 1-in. SCHEDULE 80 PVC THREADED AND COUPLED

UPPER TRANSDUCER INLET AT 1056.5 (ft bgs)
SCREENED FROM 1055.4 TO 1057.11 (ft bgs)
LOWER TRANSDUCER AT 1056.5 (ft bgs)

PUMP ASSEMBLY
SIZE/TYPE 4.0-in. GRUNDFOS
PUMP AND SHROUD 1059.1 TO 1063.3
PUMP MOTOR
SIZE/TYPE 3.0 HP FRANKLIN ELECTRIC
MOTOR AND SHROUD 1063.3 TO 1067.3
UPPER APV INTAKE 1071.2 TO 1071.5 (ft bgs)
LIQUID INFLATION CHAMBER 1073.1 TO 1077.7 (ft bgs)

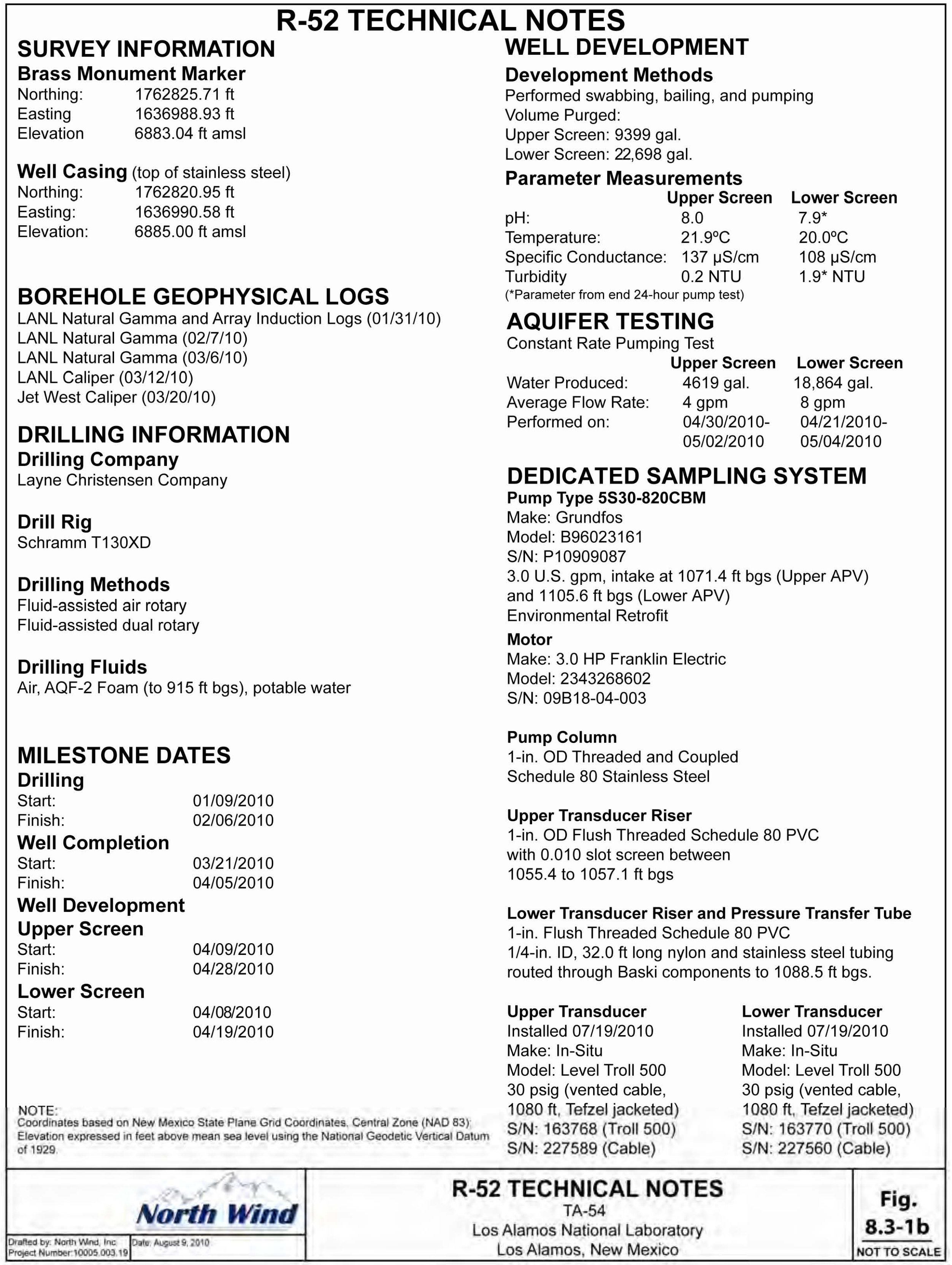
VITON WRAPPED PACKER 1081.7 TO 1086.5 (ft bgs)

LOWER TRANSDUCER INLET 1088.5 (ft bgs)
SIZE/TYPE 1/4-in. NYLON AND STAINLESS TUBING
LOWER APV INTAKE 1105.5 TO 1105.8 (ft bgs)

Drafted By: North Wind, Inc.
Project Number: 10005.003.19
Date: August 9, 2010

MONITORING WELL R-52 AS-BUILT DIAGRAM
TA -54
Los Alamos National Laboratory
Los Alamos, New Mexico

Figure 8.3-1a As-built schematic for regional well R-52



R-52 TECHNICAL NOTES

SURVEY INFORMATION

Brass Monument Marker

Northing:	1762825.71 ft
Easting	1636988.93 ft
Elevation	6883.04 ft amsl

Well Casing (top of stainless steel)

Northing:	1762820.95 ft
Easting:	1636990.58 ft
Elevation:	6885.00 ft amsl

BOREHOLE GEOPHYSICAL LOGS

LANL Natural Gamma and Array Induction Logs (01/31/10)
LANL Natural Gamma (02/7/10)
LANL Natural Gamma (03/6/10)
LANL Caliper (03/12/10)
Jet West Caliper (03/20/10)

DRILLING INFORMATION

Drilling Company

Layne Christensen Company

Drill Rig

Schramm T130XD

Drilling Methods

Fluid-assisted air rotary
Fluid-assisted dual rotary

Drilling Fluids

Air, AQF-2 Foam (to 915 ft bgs), potable water

MILESTONE DATES

Drilling

Start:	01/09/2010
Finish:	02/06/2010

Well Completion

Start:	03/21/2010
Finish:	04/05/2010

Well Development

Upper Screen

Start:	04/09/2010
Finish:	04/28/2010

Lower Screen

Start:	04/08/2010
Finish:	04/19/2010

NOTE:
Coordinates based on New Mexico State Plane Grid Coordinates, Central Zone (NAD 83); Elevation expressed in feet above mean sea level using the National Geodetic Vertical Datum of 1929.

WELL DEVELOPMENT

Development Methods

Performed swabbing, bailing, and pumping
Volume Purged:
Upper Screen: 9399 gal.
Lower Screen: 22,698 gal.

Parameter Measurements

	Upper Screen	Lower Screen
pH:	8.0	7.9*
Temperature:	21.9ºC	20.0ºC
Specific Conductance:	137 µS/cm	108 µS/cm
Turbidity	0.2 NTU	1.9* NTU

(*Parameter from end 24-hour pump test)

AQUIFER TESTING

Constant Rate Pumping Test

	Upper Screen	Lower Screen
Water Produced:	4619 gal.	18,864 gal.
Average Flow Rate:	4 gpm	8 gpm
Performed on:	04/30/2010- 05/02/2010	04/21/2010- 05/04/2010

DEDICATED SAMPLING SYSTEM

Pump Type 5S30-820CBM
Make: Grundfos
Model: B96023161
S/N: P10909087
3.0 U.S. gpm, intake at 1071.4 ft bgs (Upper APV) and 1105.6 ft bgs (Lower APV)
Environmental Retrofit

Motor
Make: 3.0 HP Franklin Electric
Model: 2343268602
S/N: 09B18-04-003

Pump Column
1-in. OD Threaded and Coupled
Schedule 80 Stainless Steel

Upper Transducer Riser
1-in. OD Flush Threaded Schedule 80 PVC
with 0.010 slot screen between
1055.4 to 1057.1 ft bgs

Lower Transducer Riser and Pressure Transfer Tube
1-in. Flush Threaded Schedule 80 PVC
1/4-in. ID, 32.0 ft long nylon and stainless steel tubing routed through Baski components to 1088.5 ft bgs.

Upper Transducer	Lower Transducer
Installed 07/19/2010	Installed 07/19/2010
Make: In-Situ	Make: In-Situ
Model: Level Troll 500	Model: Level Troll 500
30 psig (vented cable, 1080 ft, Tefzel jacketed)	30 psig (vented cable, 1080 ft, Tefzel jacketed)
S/N: 163768 (Troll 500)	S/N: 163770 (Troll 500)
S/N: 227589 (Cable)	S/N: 227560 (Cable)

North Wind
Drafted by: North Wind, Inc
Project Number:10005.003.19
Date: August 9, 2010

R-52 TECHNICAL NOTES
TA-54
Los Alamos National Laboratory
Los Alamos, New Mexico

Fig. 8.3-1b
NOT TO SCALE

Figure 8.3-1b Technical notes for regional well R-52

Table 3.1-1
Fluid Quantities Used during R-52 Drilling and Well Construction

Date	Water (gal.)	Cumulative Water (gal.)	AQF-2 Foam (gal.)	Cumulative AQF-2 Foam (gal.)
01/9/2010	4300	4300	5	5
01/11/2010	1500	5800	5	10
01/12/2010	1700	7500	n/a*	n/a
01/13/2010	800	8300	n/a	n/a
01/14/2010	4400	12,700	n/a	n/a
01/15/2010	750	13,450	n/a	n/a
01/17/2010	6500	19,950	n/a	n/a
01/18/2010	500	20,450	n/a	n/a
01/19/2010	100	20,550	5	15
01/22/2010	1500	22,050	n/a	n/a
01/23/2010	700	22,750	7	22
01/24/2010	2300	25,050	15	37
01/25/2010	1200	26,250	5	42
01/26/2010	2500	28,750	n/a	n/a
01/27/2010	5000	33,750	n/a	n/a
01/28/2010	1800	35,550	n/a	n/a
01/29/2010	9700	45,250	n/a	n/a
01/30/2010	3900	49,150	n/a	n/a
02/4/2010	2000	51,150	n/a	n/a
02/5/2010	3200	54,350	n/a	n/a
02/6/2010	5000	59,350	n/a	n/a
02/11/2010	6300	65,650	n/a	n/a
02/13/2010	300	65,950	n/a	n/a
02/15/2010	2000	67,950	n/a	n/a
03/3/2010	500	68,450	n/a	n/a
03/6/2010	3500	71,950	n/a	n/a
03/7/2010	1000	72,950	n/a	n/a
03/8/2010	500	73,450	n/a	n/a
03/12/2010	4000	77,450	n/a	n/a
03/17/2010	7200	84,650	n/a	n/a
03/19/2010	1800	86,450	n/a	n/a
03/23/2010	1900	88,350	n/a	n/a
03/24/2010	4620	92,970	n/a	n/a
03/25/2010	1980	94,950	n/a	n/a

Table 3.1-1 (continued)

Date	Water (gal.)	Cumulative Water (gal.)	AQF-2 Foam (gal.)	Cumulative AQF-2 Foam (gal.)
03/26/2010	2280	97,230	n/a	n/a
03/27/2010	4980	102,210	n/a	n/a
03/28/2010	5110	107,320	n/a	n/a
03/29/2010	4200	111,520	n/a	n/a
03/30/2010	7530	119,050	n/a	n/a
04/1/2010	7690	126,740	n/a	n/a
04/2/2010	10,520	137,260	n/a	n/a
04/3/2010	5930	143,190	n/a	n/a
04/4/2010	20,130	163,320	n/a	n/a
04/5/2010	20,485	183,805	n/a	n/a
Total Water Volume (gal.)				
R-52	183,805			

* n/a = Not applicable.

Table 4.2-1
Summary of Groundwater Screening Samples Collected during Drilling and Well Development of Well R-52

Location ID	Sample ID	Date Collected	Collection Depth (ft bgs)	Sample Type	Analysis
Drilling					
R-52	GW52-10-11189	1/27/10	916	Groundwater (bailed)	Metals, cations, anions (including perchlorate), HE, VOCs, LH3
R-52	GW52-10-11182	2/6/10	1054.0	Groundwater (airlifted)	Metals, cations, anions (including perchlorate), HE, VOCs, LH3
R-52	GW52-10-11849	2/6/10	1174.5	Groundwater (bailed)	Metals, cations, anions (including perchlorate), HE, VOCs, LH3
Well Development					
R-52	GW52-10-15463	4/17/10	1112	Groundwater (bailed)	TOC
R-52	GW52-10-15464	4/18/10	1112	Groundwater (bailed)	TOC
R-52	GW52-10-15465	4/19/10	1112	Groundwater (bailed)	TOC, metals, cations, anions
R-52	GW52-10-11184	4/26/10	1035	Groundwater (airlifted)	TOC
R-52	GW52-10-11185	4/27/10	1055	Groundwater (airlifted)	TOC
R-52	GW52-10-11188	4/28/10	1055	Groundwater (airlifted)	TOC, metals, cations, anions

Table 6.0-1
R-52 Logging Runs

Date	Type of Log	Depth (ft bgs)	Description
01/31/10	Video	0–710	Laboratory video log run. Video shows bottom of 18-in. steel casing at 560 ft bgs, water at 701 ft bgs, and notable fractures from 608 to 690 ft bgs.
01/31/10	Gamma	0–941.5	Laboratory gamma log run to 941.4 ft bgs
01/31/10	Induction	0–940.4	Laboratory induction log run to 940.4 ft bgs
02/07/10	Gamma	0–1172.9	Laboratory gamma log run to total depth of 1172.9 ft bgs
03/06/10	Gamma	0–1162	Laboratory gamma log to determine if casing shoe was cut. Increase in gamma signal at 572.0 ft bgs indicated bottom of 18-in. steel casing. Increase at 1160 ft bgs. Decrease at 1155 ft bgs on way back out of hole. Results inconclusive as to casing being cut.
03/12/10	Video	0–1162	Laboratory video log run to determine if casing was cut. Cloudy water obscured camera lens below 1130 ft bgs. Even light distribution around 1160 ft bgs implied that casing was not cut.
03/12/10	Caliper	0–1166.8	Laboratory caliper run to determine if casing was cut. Ran caliper three times, no deviation shown on any of three attempts. Concluded that casing was not cut.
03/19/10	Video	0–1130	Laboratory video log run to determine if casing was cut. Video log showed open hole below cut at ~1125.3 ft bgs.
03/20/10	Caliper	0–1130	Jet West caliper log run to confirm that casing was cut. Caliper log clearly indicated the cut at 1125.3 ft bgs.

Table 7.2-1
R-52 Annular Fill Materials

Material	Volume (ft^3)
Surface seal: 100 wt% Portland cement	183.6
Upper seal: 0.375-in. bentonite chips	1280.5
Grout seal around 18-in. casing: 100 wt% Portland cement	30.0
Intermediate seal: 0.375-in. bentonite chips	507.2
Transition sand collar: 20/40 silica sand	4.0
Primary filter pack (upper screen): 10/20 silica sand	33.5
Interscreen seal: 0.375-in. bentonite chips	64.2
Transition sand collar: 20/40 silica sand	2.0
Primary filter pack (lower screen): 10/20 silica sand	33.0
Lower seal: 0.375-in. bentonite chips	31.3

Table 8.5-1
R-52 Survey Coordinates

Identification	Northing	Easting	Elevation
R-52 brass monument marker	1762825.71	1636988.93	6883.04
R-52 ground surface	1762835.57	1636987.27	6882.55
R-52 top of protective casing	1762821.05	1636990.60	6885.58
R-52 top of well casing	1762820.95	1636990.58	6885.00

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

Table 8.6-1
Summary of Waste Samples Collected during Drilling and Development of R-52

Sample ID/Event ID	Date, Time Collected	Description	Sample Matrix
WST52-10-11327/2583	1/14/10, 1510	Decon water	Liquid
WST52-10-11326/2583	1/14/10, 1510	Trip blank	Liquid
MD54-10-12060/2613	1/29/10, 1438	Secondary containment	Liquid
WST54-10-12091/2615	2/17/10, 1330	Decon water	Liquid
WST54-10-12092/2615	2/17/10, 1330	Trip blank	Liquid
WST52-10-15736/2750	4/16/10, 0950	Drill cuttings	Soil
WST52-10-15737/2750	4/16/10, 0950	Trip blank	Soil
WST52-10-15863/2763	4/18/10, 1435	Decon water	Liquid
WST52-10-15862/2763	4/18/10, 1435	Trip blank	Liquid
WST52-10-15554/2740	4/21/10, 1535	Drilling fluids	Liquid
WST52-10-15555/2740	4/21/10, 1535	Drilling fluids	Liquid
WST52-10-15556/2740	4/21/10, 1535	Drilling fluids	Liquid
WST52-10-15557/2740	4/21/10, 1535	Trip blank	Liquid
WST52-10-15619/2744	4/21/10, 0817	Development water	Liquid
WST52-10-15620/2744	4/21/10, 0830	Development water	Liquid
WST52-10-15621/2744	4/21/10, 0903	Development water	Liquid
WST52-10-15622/2744	4/21/10, 0826	Trip blank	Liquid
WST52-10-16647/2592	4/27/10, 0945	Development water	Liquid
WST52-10-16648/2592	4/27/10, 0945	Development water	Liquid
WST52-10-16649/2592	4/27/10, 0945	Development water	Liquid
WST52-10-16650/2592	4/27/10, 0945	Trip blank	Liquid
WST52-10-16651/2793	5/3/10, 1110	Development water	Liquid
WST52-10-16652/2793	5/3/10, 1110	Development water	Liquid
WST52-10-16653/2793	5/3/10, 1110	Development water	Liquid
WST52-10-16654/2793	5/3/10, 1110	Trip blank	Liquid

Appendix A

Well R-52 Borehole Lithologic Log

Borehole Identification (ID): R-52	**Technical Area (TA):** 54	**Page:** 1 of 18
Drilling Company: Layne Christensen Co.	**Start Date/Time:** 1/9/10 1021	**End Date/Time:** 2/6/10 1500
Drilling Method: Air Rotary	**Machine: Schramm** T130XD RIG T25	**Sampling Method:** Grab
Ground Elevation: 6885.55		**Total Depth:** 1175 ft bgs
Driller: H. Waddell, K. Keller, R. Wall, J. Allen	**Site Geologists:** T. Klepfer, B. Lucero, G. Kinsman, S. Thomas, M. Whitson, D. Oshlo, D. Staires	

Depth (ft bgs)	**Lithology**	**Lithologic Symbol**	**Notes**
0–10	**QUATERNARY ALLUVIUM:** Fine to medium grained alluvial sediments (ML), moderately to highly weathered, pinkish gray (7.5YR7/2) to light brown (7.5YR6/3), subangular to subrounded fragments. WR: Fine to medium grained alluvial silts and sands with minor gravels, minor quartz and sanidine crystals. Abundant silt in matrix; possible eolian silt in soil component. +10F: 75% welded tuff fragments with 15-20% milky to clear quartz and sanidine crystals. 5-10% volcanic lithic fragments, with minor Fe-oxide staining. +35F: 75-80% quartz and sanidine crystals, 15-20% tuff fragments, with minor volcanic lithic fragments. (Minor white orbicular inclusions noted in quartz crystals).	**Qal**	Note: Construction gravels, base course fill.
10–35	**UNIT 2 OF THE TSHIREGE MEMBER OF THE BANDELIER TUFF:** Tuff, light gray (5YR7/1) to gray (5YR56/1), devitrified, poorly to moderately welded, crystal rich. +10F: 60-65% poorly to moderately welded pumice fragments with 10-20% quartz and sanidine crystals, and 10-20% felsic volcanic lithic fragments, some with minor Fe-oxide staining. +35F: 90-95% quartz and sanidine crystals, 5% tuff fragments, 5% volcanic lithic fragments with minor Fe-oxide staining. Minor bipyramidal quartz noted.	**Qbt 2**	
35–50	**UNIT 1v OF THE TSHIREGE MEMBER OF THE BANDELIER TUFF:** Tuff, gray (5YR6/1) to pinkish gray (7.5YR6/2), devitrified, poorly to nonwelded and poorly indurated, crystal rich. WR: silty to fine sandy matrix. +10F: 40-45% quartz and sanidine crystals, 40-45% intermediate composition volcanic lithic fragments, and 5% tuff fragments. +35F: 90-95% quartz and sanidine crystals, 3-5% intermediate composition and Fe-oxide stained volcanic lithic fragments, and 1-2% poorly welded tuff fragments.	**Qbt 1v**	
50–80	Tuff, gray and shades of gray (5YR6/1 to 5YR5/1), devitrified, poorly welded and poorly indurated, crystal rich. WR: fine sandy matrix. +10F: 65% quartz and sanidine crystals, with minor silty coating on most crystals, 35% intermediate composition volcanic lithic fragments, with spotty Fe-oxide staining. Trace volcanic tuff fragments. +35F: 95% quartz and sanidine crystals, 5% intermediate composition volcanic lithic fragments. Minor bipyramidal and orbicular inclusions in quartz crystals noted.	**Qbt 1v**	

Borehole Identification (ID): R-52	**Technical Area (TA):** 54	**Page:** 2 of 18
Drilling Company: Layne Christensen Co.	**Start Date/Time:** 1/9/10 1021	**End Date/Time:** 2/6/10 1500
Drilling Method: Air Rotary	**Machine: Schramm** T130XD RIG T25	**Sampling Method:** Grab
Ground Elevation: 6885.55		**Total Depth:** 1175 ft bgs
Driller: H. Waddell, K. Keller, R. Wall, J. Allen	**Site Geologists:** T. Klepfer, B. Lucero, G. Kinsman, S. Thomas, M. Whitson, D. Oshlo, D. Staires	

Depth (ft bgs)	Lithology	Lithologic Symbol	Notes
80–90	Tuff, very dark gray (7.5YR3/1) to dark brown (7.5YR3/2), devitrified, poorly welded and poorly indurated, crystal rich. WR: Very clayey to silty texture. +10F: 60% quartz and sanidine crystals, 15-20% intermediate composition volcanic lithic fragments displaying minor Fe-oxide staining, and 15-20% tuff fragments that are generally well indurated. +35F: 95-100% quartz and sanidine crystals, with trace to 5% volcanic lithic fragments, trace tuff fragments. Minor Fe-oxide staining on lithic fragments, and trace bipyramidal quartz noted.	**Qbt 1v**	
90–95	No cuttings were recovered in this interval.		
95–100	Tuff, very dark gray (7.5YR3/1) to dark brown (7.5YR3/2), poorly welded and poorly indurated. WR: Very clayey to silty texture. +10F: 60% quartz and sanidine crystals, 35% tuff fragments, 5% intermediate composition volcanic lithic fragments displaying Fe-oxide staining. +35F: 90-95% quartz and sanidine crystals, with 5% volcanic lithic fragments, trace tuff fragments. Minor Fe-oxide staining on lithic fragments, and trace bipyramidal quartz noted.	**Qbt 1v**	
100–105	Tuff, gray (5YR5/1), to reddish gray (5YR5/2), devitrified, poorly welded and poorly indurated, crystal rich. WR: Sandy to silty texture. +10F: 90% quartz and sanidine crystals, 5-10% intermediate composition volcanic lithic fragments displaying minor Fe-oxide staining. +35F: 90-95% quartz and sanidine crystals, with 5% volcanic lithic fragments. Minor Fe-oxide staining on lithic fragments, and trace bipyramidal quartz noted with minor orbicular inclusion in some crystals.	**Qbt 1v**	
105–110	Tuff, gray (5YR5/1), to reddish gray (5YR5/2), poorly welded and poorly indurated. WR: Sandy to silty texture. +35F: 90% quartz and sanidine crystals, 5-10% intermediate composition volcanic lithic fragments displaying minor Fe-oxide staining. +60F: 90% quartz and sanidine crystals, with 5% tuff fragments, trace lithic fragments. Minor Fe-oxide staining on lithic fragments.	**Qbt 1v**	
110–115	Tuff, gray (5YR5/1) to dark gray (5YR4/1), devitrified, poorly welded and poorly indurated. WR: Sandy to silty texture. +10F: 50% quartz and sanidine crystals, 30% welded tuff fragments, 15-20% intermediate composition volcanic lithic fragments displaying minor Fe-oxide staining. +35F: 90% quartz and sanidine crystals, with 5% tuff fragments, trace lithic fragments. Minor Fe-oxide staining on lithic fragments.	**Qbt 1v**	

Borehole Identification (ID): R-52	**Technical Area (TA):** 54	**Page:** 3 of 18
Drilling Company: Layne Christensen Co.	**Start Date/Time:** 1/9/10 1021	**End Date/Time:** 2/6/10 1500
Drilling Method: Air Rotary	**Machine: Schramm** T130XD RIG T25	**Sampling Method:** Grab
Ground Elevation: 6885.55		**Total Depth:** 1175 ft bgs
Driller: H. Waddell, K. Keller, R. Wall, J. Allen	**Site Geologists:** T. Klepfer, B. Lucero, G. Kinsman, S. Thomas, M. Whitson, D. Oshlo, D. Staires	

Depth (ft bgs)	**Lithology**	**Lithologic Symbol**	**Notes**
115–125	Tuff, gray (5YR5/1) to pinkish gray (5YR6/2), poorly welded. WR: Silty texture. +35F: 85-90% quartz and sanidine crystals, 10-15% intermediate composition lithic fragments, trace tuff fragments. +60F: 60% quartz and sanidine crystals, 15% intermediate composition lithic fragments, 15-20% welded tuff fragments. Minor Fe-oxide staining on some lithics.	**Qbt 1v**	
125–140	Tuff, brown (7.5YR5/2) to brown (7.5YR5/3), poorly welded. WR: Silty texture. +10F: 80-85% intermediate composition lithic fragments (up to 12 mm), 15-20% welded tuff fragments, 5% quartz and sanidine crystals. +35F: 75-80% quartz and sanidine crystals, 10-15% lithic fragments, 5-10% welded tuff fragments. Minor Fe-oxide staining on most lithic fragments. Wormy and orbicular inclusions noted in quartz fragments. Bipyramidal quartz noted.	**Qbt 1v**	
140–160	**UNIT 1g OF THE TSHIREGE MEMBER OF THE BANDELIER TUFF:** Tuff, pinkish gray (7.5YR6/2) to pink (7.5YR7/3), poorly to nonwelded vitric pumice. WR: Silty texture. +10F: 60-65% intermediate composition volcanic lithic fragments, 10-15% tuff fragments (up to 3 mm), 20-25% pinkish white to white vitric pumice fragments. Minor Fe-oxide staining on lithics, and trace bipyramidal quartz noted. +35F: 60-65% quartz (some smoky quartz crystals) and sanidine crystals (bipyramidal quartz, as well as wormy and white orbicular inclusions noted in some crystals), 10-15% intermediate composition volcanic lithic fragments with minor Fe-oxide staining, and 10-15% vitric pumice and tuff fragments.	**Qbt 1g**	
160–170	Tuff, pinkish gray (7.5YR6/2) to pink (7.5YR7/3), poorly to nonwelded vitric pumice. WR: Silty texture. +10F: 90-95% welded tuff and vitric pumice fragments, trace intermediate composition volcanic lithic fragments. +35F: 60-65% quartz and sanidine crystals (trace bipyramidal quartz), 20-25% vitric pumice with welded tuff (mostly pumice) fragments, 10-15% intermediate composition volcanic lithic fragments.	**Qbt 1g**	
170–185	Tuff, pinkish gray (7.5YR6/2) to pink (7.5YR7/3), poorly to nonwelded vitric pumice. WR: Silty texture. +10F: 90-95% welded tuff and vitric pumice fragments, trace intermediate composition volcanic lithic fragments. +35F: 55-60% quartz and sanidine crystals (trace bipyramidal quartz), 30-35% welded tuff with vitric pumice fragments, 10-15% intermediate composition volcanic lithic fragments.	**Qbt 1g**	

Borehole Identification (ID): R-52	**Technical Area (TA):** 54	**Page:** 4 of 18
Drilling Company: Layne Christensen Co.	**Start Date/Time:** 1/9/10 1021	**End Date/Time:** 2/6/10 1500
Drilling Method: Air Rotary	**Machine: Schramm** T130XD RIG T25	**Sampling Method:** Grab
Ground Elevation: 6885.55		**Total Depth:** 1175 ft bgs
Driller: H. Waddell, K. Keller, R. Wall, J. Allen	**Site Geologists:** T. Klepfer, B. Lucero, G. Kinsman, S. Thomas, M. Whitson, D. Oshlo, D. Staires	

Depth (ft bgs)	**Lithology**	**Lithologic Symbol**	**Notes**
185–195	Tuff, pinkish gray (7.5YR6/2) to pink (7.5YR7/3), poorly to nonwelded. WR: Silty texture. +10F: 70-75% volcanic tuff and vitric pumice fragments, 20-25% intermediate composition volcanic lithic fragments, trace quartz and sanidine crystals. +35F: 70-75% quartz and sanidine crystals, 15-20% volcanic tuff fragments, 5% intermediate composition volcanic tuff fragments.	**Qbt 1g**	
195–205	Tuff, pinkish white (7.5YR8/2) to pinkish gray (7.5YR7/2), poorly to nonwelded. WR: Silty texture. +10F: 50% volcanic tuff fragments, 50% intermediate composition volcanic lithic fragments. Minor Fe-oxide staining on most lithic fragments. +35F: 70-75% quartz and sanidine crystals, 15-20% welded tuff fragments, 5-10% intermediate composition volcanic lithic fragments. Minor obsidian shards noted.	**Qbt 1g**	
205–225	Tuff, pinkish white (7.5YR8/2) to pinkish gray (7.5YR7/2), poorly to nonwelded. WR: Moderately silty texture, less than sections above. +10F: 60-65% tuff fragments, 20-25% intermediate composition volcanic lithic fragments, 5% quartz and sanidine crystals. Minor light-orange Fe-oxide staining on lithic fragments. +35F: 75-80% quartz and sanidine crystals, 10-15 % tuff fragments, 10-15% intermediate composition volcanic lithic fragments. Bipyramidal quartz and minor obsidian shards noted.	**Qbt 1g**	
225–230	**CERRO TOLEDO INTERVAL:** Volcaniclastic (epiclastic) sediments, very pale brown (10YR7/3) to pale brown (10YR6/3), poorly graded gravel with minor sand component. Clasts subangular to subrounded. +10F: Detrital constituents (up to 10 mm) composed of 95% varied intermediate composition volcanic lithic fragments, and 5% white to yellowish white vitric pumice fragments. Noted black obsidian present.	**Qct**	Contact between Qbt 1g and Qct at 225 ft bgs.
230–240	Volcaniclastic sediments, very pale brown (10YR7/3) to pale brown (10YR6/3), well graded coarse sands (SW) with minor gravel component (up to 4 mm). Clasts subangular to subrounded. +10F: Detrital constituents (up to 3 mm) composed of 60-65% white to yellowish white vitric pumice fragments and 35-40% varied intermediate composition volcanic lithic fragments. Noted black obsidian present.	**Qct**	

Borehole Identification (ID): R-52	**Technical Area (TA):** 54	**Page:** 5 of 18
Drilling Company: Layne Christensen Co.	**Start Date/Time:** 1/9/10 1021	**End Date/Time:** 2/6/10 1500
Drilling Method: Air Rotary	**Machine: Schramm** T130XD RIG T25	**Sampling Method:** Grab
Ground Elevation: 6885.55		**Total Depth:** 1175 ft bgs
Driller: H. Waddell, K. Keller, R. Wall, J. Allen	**Site Geologists:** T. Klepfer, B. Lucero, G. Kinsman, S. Thomas, M. Whitson, D. Oshlo, D. Staires	

Depth (ft bgs)	**Lithology**	**Lithologic Symbol**	**Notes**
240–250	Sediments, very pale brown (10YR7/4) to light yellowish brown (10YR6/4), silts and sands, poorly to nonwelded, vitric pumices. WR: silty to sandy texture with very fine to coarse sand-size lithics and crystals. +10F: 85-90% pale orange to pinkish tuff fragments, some vitric fibrous pumice fragments. 10-15% aphanitic to porphyritic intermediate volcanic lithics including dacite and andesite. +35F: composed of 45-50% intermediate composition volcanic lithics, 45-50% tuff and pumice fragments, and 5-10 % quartz and sanidine crystals.	**Qct**	
250–275	**OTOWI MEMBER OF THE BANDELIER TUFF:** Tuff, very pale brown (10YR8/3) to pinkish white (7.5YR8/2), poorly welded. WR: very silty to sandy texture, with fine sand-size lithic fragments and quartz and sanidine crystals. +10F: 55-60% aphanitic to porphyritic intermediate composition volcanic lithics, including dacites and andesites. Minor pyrite stringers associated with singular large (~15 mm) volcanic lithic. 40-45% tuff and pumice fragments. Minor Fe-oxide staining on some lithic fragments. +35F: 45-50% tuff and pumice fragments, 25-30% quartz and sanidine crystals, 15-20% intermediate composition volcanic lithic fragments. Minor biotite fragments; bipyramidal and smoky quartz crystals noted.	**Qbo**	Note: Contact between Qct and Qbo is noted at 250 ft bgs.
275–280	Tuff, pink (7.5YR8/3) to very pale brown (10YR8/4), poorly welded. WR: very silty to sandy texture, with fine sand-size lithic fragments and quartz and sanidine crystals. +10F: 70-75% aphanitic to porphyritic intermediate composition volcanic lithic fragments (up to 7 mm). 25-30% tuff and pumice fragments. +35F: 35-40% tuff and pumice fragments, 30-35% quartz and sanidine crystals, and 20-25% volcanic lithic fragments.	**Qbo**	
280–290	Tuff, pink (7.5YR8/3) to very pale brown (10YR8/4), poorly welded. WR: very silty to sandy texture, with fine sand-size lithic fragments and quartz and sanidine crystals. +10F: 65-70% tuff and pumice fragments, 25-30% aphanitic to porphyritic intermediate composition volcanic lithic fragments (up to 3 mm). +35F: 55-60% tuff and pumice fragments, 15-20% quartz and sanidine crystals, and 15-20% volcanic lithic fragments. Trace bipyramidal quartz noted.	**Qbo**	

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Drilling Company: Layne Christensen Co.	**Start Date/Time:** 1/9/10 1021	**End Date/Time:** 2/6/10 1500
Drilling Method: Air Rotary	**Machine: Schramm** T130XD RIG T25	**Sampling Method:** Grab
Ground Elevation: 6885.55		**Total Depth:** 1175 ft bgs
Driller: H. Waddell, K. Keller, R. Wall, J. Allen	**Site Geologists:** T. Klepfer, B. Lucero, G. Kinsman, S. Thomas, M. Whitson, D. Oshlo, D. Staires	

Depth (ft bgs)	**Lithology**	**Lithologic Symbol**	**Notes**
290–300	Tuff, pink (7.5YR8/3) to very pale brown (10YR7/4), poorly welded. WR: silty to sandy texture, with fine sand-size lithic fragments and quartz and sanidine crystals. +10F: 80-85% varieties of aphanitic and porphyritic felsic to intermediate composition lithic fragments, (up to 10 mm) including andesite and dacite. Minor Fe-oxide staining present on some lithic fragments. 15-20% tuff and pumice fragments. +35F: 60-65% quartz and sanidine crystals, 20-25% tuff and pumice fragments, 15-20% intermediate composition volcanic lithic fragments.	**Qbo**	
300–315	Tuff, white (10YR8/1) to very pale brown (10YR8/2), poorly welded. WR: silty to sandy texture, with fine sand-size lithic fragments and quartz and sanidine crystals. +10F: 65-70% tuff and pumice fragments, 30-35% varieties of intermediate composition volcanic lithics (up to 10 mm) including andesite and dacite. +35F: 65-70% quartz and sanidine crystals, 15-20% intermediate composition volcanic lithics, 5-10% tuff and pumice fragments. Bipyramidal quartz noted.	**Qbo**	
315–320	Tuff, very pale brown (10YR8/3) to light yellowish brown (10YR6/4), poorly welded. WR: silty to sandy texture, with fine sand-size lithic fragments and quartz and sanidine crystals. +10F: 65-70% tuff and fibrous vitric pumice fragments, 30-35% intermediate composition volcanic lithic fragments (up to 10 mm) including andesite and dacite. +35F: 85-90% tuff and vitric pumice fragments, 10-15% quartz and sanidine crystals.	**Qbo**	
320–335	Tuff, very pale brown (10YR8/3) to light yellowish brown (10YR6/4), poorly welded. WR: silty to sandy texture, with fine sand-size lithic fragments and quartz and sanidine crystals. +10F: 65-70% intermediate composition volcanic lithic fragments (up to 10 mm). 30-35% tuff and fibrous vitric pumice fragments. +35F: 85-90% quartz and sanidine crystals, 10-15% tuff and vitric pumice fragments.	**Qbo**	
335–355	Tuff, very pale brown (10YR8/3) to light yellowish brown (10YR6/4), poorly welded. WR: silty to sandy texture, with fine sand-size lithic fragments and quartz and sanidine crystals. +10F: 65-70% tuff and vitric pumice fragments, 30-35% intermediate composition volcanic lithic fragments (up to 10 mm) including andesite and dacite. +35F: 85-90% tuff and vitric pumice fragments, 10-15% quartz and sanidine crystals.	**Qbo**	

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Drilling Company: Layne Christensen Co.	**Start Date/Time:** 1/9/10 1021	**End Date/Time:** 2/6/10 1500
Drilling Method: Air Rotary	**Machine: Schramm** T130XD RIG T25	**Sampling Method:** Grab
Ground Elevation: 6885.55		**Total Depth:** 1175 ft bgs
Driller: H. Waddell, K. Keller, R. Wall, J. Allen	**Site Geologists:** T. Klepfer, B. Lucero, G. Kinsman, S. Thomas, M. Whitson, D. Oshlo, D. Staires	

Depth (ft bgs)	**Lithology**	**Lithologic Symbol**	**Notes**
355–375	Tuff, very pale brown (10YR8/3) to pale brown (10YR6/3), poorly welded. WR: silty to sandy texture, with sand-size lithic fragments and quartz and sanidine crystals. +10F: 60-65% aphanitic and porphyritic intermediate composition volcanic lithic fragments, 30-35% tuff and vitric pumice fragments. +35F: 70-75% intermediate composition lithic fragments, 15-20% quartz and sanidine crystals, 10-15% tuff and vitric pumice fragments. Minor orbicular inclusions in quartz crystals noted.	**Qbo**	
375–400	Tuff, very pale brown (10YR8/3) to pale brown (10YR6/3), poorly welded. WR: silty to sandy texture, with fine to coarse sand-size lithic fragments and quartz and sanidine crystals. +10F: 75-80% aphanitic and porphyritic intermediate composition volcanic lithic fragments, 20-25% tuff and vitric pumice fragments. +35F: 65-70% quartz and sanidine crystals, 20-25% intermediate composition lithic fragments, 5% tuff and vitric pumice fragments. Trace bipyramidal and minor orbicular inclusions in quartz crystals noted.	**Qbo**	
400–425	Tuff, white (10YR8/1) to very pale brown (10YR7/3), poorly to nonwelded, vitric tuff. WR: silty to gravelly texture with pumice fragments, fine to coarse lithic fragments and quartz and sanidine crystals. +10F: 90-95% aphanitic and porphyritic intermediate composition volcanic lithic fragments, 5-10% tuff and vitric pumice fragments, trace quartz crystals. +35F: 55-65% quartz and sanidine crystals, 50-65% intermediate composition lithic fragments, 5% tuff and vitric pumice fragments. Trace bipyramidal quartz crystals.	**Qbo**	
425–430	Tuff, white (10YR8/1), poorly to nonwelded. WR: silty to gravelly texture with pumice fragments, fine to coarse lithic fragments and quartz and sanidine crystals. +10F: 5% aphanitic and porphyritic intermediate composition volcanic lithic fragments, 95% tuff and vitric pumice fragments, trace quartz crystals. +35F: 35% quartz and sanidine crystals, 10% intermediate composition lithic fragments, 55% tuff and vitric pumice fragments.	**Qbo**	
430–440	Tuff, white (10YR8/1) to light gray (10YR7/1), nonwelded. WR: silty to gravelly texture with pumice fragments, fine to coarse lithic fragments and quartz and sanidine crystals. +10F: 85-90% aphanitic and porphyritic intermediate composition volcanic lithic fragments, 10-15% tuff and vitric pumice fragments, trace quartz crystals. +35F: 50-65% quartz and sanidine crystals, 45-50% intermediate composition lithic fragments, 5-10% tuff and vitric pumice fragments.	**Qbo**	

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Drilling Company: Layne Christensen Co.	**Start Date/Time:** 1/9/10 1021	**End Date/Time:** 2/6/10 1500
Drilling Method: Air Rotary	**Machine: Schramm** T130XD RIG T25	**Sampling Method:** Grab
Ground Elevation: 6885.55		**Total Depth:** 1175 ft bgs
Driller: H. Waddell, K. Keller, R. Wall, J. Allen	**Site Geologists:** T. Klepfer, B. Lucero, G. Kinsman, S. Thomas, M. Whitson, D. Oshlo, D. Staires	

Depth (ft bgs)	Lithology	Lithologic Symbol	Notes
440–450	Tuff, white (10YR8/1) to very pale brown (10YR8/2), poorly to nonwelded. WR: silty to sandy texture with pumice fragments, fine to coarse lithic fragments and quartz and sanidine crystals. +10F: 25-30% aphanitic and porphyritic intermediate composition volcanic lithic fragments, 70-75% tuff and vitric pumice fragments. +35F: 35-40% quartz and sanidine crystals, 30-35% intermediate composition lithic fragments, 35-40% tuff and vitric pumice fragments. Trace bipyramidal quartz and inclusions in quartz crystals.	**Qbo**	
450–460	Tuff, white (10YR8/1) to light gray (10YR7/1), poorly to nonwelded. WR: silty to gravelly texture with pumice fragments, fine to coarse lithic fragments and quartz and sanidine crystals. +10F: 75-85% aphanitic and porphyritic intermediate composition volcanic lithic fragments, 15-25% tuff and vitric pumice fragments, trace quartz and sanidine crystals. +35F: 45-55% quartz and sanidine crystals, 45-55% intermediate composition lithic fragments, 5% tuff and vitric pumice fragments. Trace bipyramidal quartz and inclusions in quartz crystals.	**Qbo**	
460–470	Tuff, white (10YR8/1) to light gray (10YR7/1), poorly to nonwelded. WR: silty to gravelly texture with pumice fragments, fine to coarse lithic fragments and quartz and sanidine crystals. +10F: 15-30% aphanitic and porphyritic intermediate composition volcanic lithic fragments, 70-85% tuff and vitric pumice fragments, trace quartz and sanidine crystals. +35F: 25-30% quartz and sanidine crystals, 20-30% intermediate composition lithic fragments, 55-60% tuff and vitric pumice fragments. Trace bipyramidal quartz and inclusions in quartz crystals.	**Qbo**	
470–475	Tuff, white (10YR8/1) to light gray (10YR7/1), poorly to nonwelded. WR: silty to gravelly texture with pumice fragments, fine to coarse lithic fragments and quartz and sanidine crystals. +10F: 95% aphanitic and porphyritic intermediate composition volcanic lithic fragments, 5% tuff and vitric pumice fragments, trace quartz and sanidine crystals. +35F: 30% quartz and sanidine crystals, 60% intermediate composition lithic fragments, 10% tuff and vitric pumice fragments. Trace bipyramidal quartz and inclusions in quartz crystals.	**Qbo**	

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Drilling Method: Air Rotary	**Machine: Schramm** T130XD RIG T25	**Sampling Method:** Grab
Ground Elevation: 6885.55		**Total Depth:** 1175 ft bgs
Driller: H. Waddell, K. Keller, R. Wall, J. Allen	**Site Geologists:** T. Klepfer, B. Lucero, G. Kinsman, S. Thomas, M. Whitson, D. Oshlo, D. Staires	

Depth (ft bgs)	**Lithology**	**Lithologic Symbol**	**Notes**
475–490	Tuff, white (10YR8/1) to light gray (10YR7/1), poorly to nonwelded. WR: silty to gravelly texture with pumice fragments, fine to coarse lithic fragments and quartz and sanidine crystals. +10F: trace aphanitic and porphyritic intermediate composition volcanic lithic fragments, 100% tuff and vitric pumice fragments, trace quartz and sanidine crystals. +35F: 20-25% quartz and sanidine crystals, 20-35% intermediate composition lithic fragments, 15-40% tuff and vitric pumice fragments. Trace bipyramidal quartz and inclusions in quartz crystals.	**Qbo**	
490–500	Tuff, white (10YR8/1) to light gray (10YR7/1), poorly to nonwelded. WR: silty to gravelly texture with pumice fragments, fine to coarse lithic fragments and quartz and sanidine crystals. +10F: 50% aphanitic and porphyritic intermediate composition volcanic lithic fragments, 50% tuff and vitric pumice fragments, trace quartz and sanidine crystals. +35F: 45% quartz and sanidine crystals, 45% intermediate composition lithic fragments, 10% tuff and vitric pumice fragments. Trace bipyramidal quartz and inclusions in quartz crystals.	**Qbo**	
500–515	Tuff, white (2.5Y8/1) to very pale brown (10YR8/3), poorly to nonwelded. WR: silty to gravelly texture with pumice fragments, fine to coarse lithic fragments and quartz and sanidine crystals. +10F: 2-4% aphanitic and porphyritic intermediate composition volcanic lithic fragments, 96-98% tuff and vitric pumice fragments. +35F: 15-25% quartz and sanidine crystals, 5-7% intermediate composition lithic fragments, 70-75% tuff and vitric pumice fragments. Trace bipyramidal quartz and inclusions in quartz crystals.	**Qbo**	
515–520	Tuff, white (2.5Y8/1) to very pale brown (10YR8/3), poorly to nonwelded. WR: silty to gravelly texture with pumice fragments, fine to coarse lithic fragments and quartz and sanidine crystals. +10F: 20% aphanitic and porphyritic intermediate composition volcanic lithic fragments, 80% tuff and vitric pumice fragments. +35F: 15-25% quartz and sanidine crystals, 5-7% intermediate composition lithic fragments, 70-75% tuff and vitric pumice fragments. Trace bipyramidal quartz and inclusions in quartz crystals.	**Qbo**	

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Drilling Method: Air Rotary	**Machine: Schramm** T130XD RIG T25	**Sampling Method:** Grab
Ground Elevation: 6885.55		**Total Depth:** 1175 ft bgs
Driller: H. Waddell, K. Keller, R. Wall, J. Allen	**Site Geologists:** T. Klepfer, B. Lucero, G. Kinsman, S. Thomas, M. Whitson, D. Oshlo, D. Staires	

Depth (ft bgs)	**Lithology**	**Lithologic Symbol**	**Notes**
520–530	Tuff, white (2.5Y8/1) to very pale brown (10YR8/3), poorly to nonwelded, vitric pumice. WR: silty to gravelly texture with pumice fragments, fine to coarse lithic fragments and quartz and sanidine crystals. +10F: 2-4% aphanitic and porphyritic intermediate composition volcanic lithic fragments, 96-98% tuff and vitric pumice fragments. +35F: 15-25% quartz and sanidine crystals, 5-7% intermediate composition lithic fragments, 70-75% tuff and vitric pumice fragments. Trace bipyramidal quartz and inclusions in quartz crystals.	**Qbo**	
530–535	**GUAJE PUMICE BED OF THE OTOWI MEMBER OF THE BANDELIER TUFF:** Tuff, white (2.5Y8/1), nonwelded. WR: silty texture with pumice fragments. +10F: 100% tuff and vitric pumice fragments. +35F: trace quartz and sanidine crystals, trace intermediate composition lithic fragments, 100% tuff and vitric pumice fragments.	**Qbog**	
535–540	Tuff, white (2.5Y8/1) to very pale brown (10YR8/3), nonwelded. WR: silty to gravelly texture with pumice fragments, fine to coarse lithic fragments and quartz and sanidine crystals. +10F: 40-50% aphanitic and porphyritic intermediate composition volcanic lithic fragments, 50-60% tuff and vitric pumice fragments, trace quartz and sanidine crystals. +35F: 15-25% quartz and sanidine crystals, 15-20% intermediate composition lithic fragments, 55-70% tuff and vitric pumice fragments. Trace bipyramidal quartz and inclusions in quartz crystals.	**Qbog**	
540–545	**PUYE FORMATION:** Volcaniclastic sediments, white (7.5YR8/1) to very pale brown (10YR8/2), poorly sorted, well-graded silts and sands (SW) with minor gravel, subangular to subrounded clasts. WR: Intermediate to mafic composition lithics, vitric and devitrified pumice fragments, tuffaceous siltstone and sandstone, minor quartz and sanidine crystals. +10F: 5-10% white pumice clasts, 45-70% aphanitic to porphyritic intermediate and mafic volcanic clasts, 10-20% tuffaceous siltstone and sandstone clasts, trace quartz clasts. +35F: 5-15%-pumice clasts, 45-60% aphanitic to porphyritic intermediate and mafic volcanic clasts, 10-25% quartz and sanidine clasts (trace bipyramidal quartz), 5-15% tuffaceous siltstone and sandstone clasts.	**Tpf**	

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Drilling Method: Air Rotary	**Machine: Schramm** T130XD RIG T25	**Sampling Method:** Grab
Ground Elevation: 6885.55		**Total Depth:** 1175 ft bgs
Driller: H. Waddell, K. Keller, R. Wall, J. Allen	**Site Geologists:** T. Klepfer, B. Lucero, G. Kinsman, S. Thomas, M. Whitson, D. Oshlo, D. Staires	

Depth (ft bgs)	**Lithology**	**Lithologic Symbol**	**Notes**
545–550	Volcaniclastic sediments, very pale orange (10YR8/2) to very dark gray (10YR3/1), poorly sorted, well-graded silts and sands (SW) with minor gravel, subangular to subrounded clasts. WR: Intermediate to mafic composition lithics, vitric and devitrified pumice fragments, tuffaceous siltstone and sandstone, minor quartz and sanidine crystals. +10F: 5-10% white pumice clasts, 45-60% aphanitic to porphyritic intermediate and mafic volcanic clasts, 30-35% tuffaceous siltstone and sandstone clasts, trace quartz clasts. +35F: 5-15%-pumice clasts, 40-45% aphanitic to porphyritic intermediate and mafic volcanic clasts, 10-25% quartz and sanidine clasts (trace bipyramidal quartz), 15-25% tuffaceous siltstone and sandstone clasts.	**Tpf**	
550–560	**CERROS DEL RIO VOLCANIC ROCKS:** Aphanitic, nonvesicular to slightly vesicular basaltic scoria, dark gray (2.5Y4/1) with traces of intermediate composition volcanic lithic fragments, pumice fragments, and quartz and sanidine crystals. +10F: 45-65% basalt fragments, 20-30% clay and lithic fragments, 5-10% pumice fragments, trace quartz and sanidine crystals. +35F: 55-60% basalt fragments, 20-30% clay and lithic fragments, 2-5% pumice fragments, 10-15% quartz and sanidine crystals.	**Tb 4**	Note: weathered, scoriaceous basalt.
560–580	Aphanitic, nonvesicular to moderately vesicular basalt and amygdaloidal basalt, gray (2.5Y5/1) to very dark gray (2.5Y3/1) with some pumice and traces of intermediate composition volcanic lithic fragments and quartz and sanidine crystals. Basalt contains notable phenocrysts of olivine and plagioclase feldspar as well as abundant clay-infilled vesicles. +10F: 65-80% basalt fragments, 5-15% clay and lithic fragments, 5-10% pumice fragments. +35F: 70-90% basalt fragments, 2-10% clay and lithic fragments, 2-5% pumice fragments, trace quartz and sanidine crystals. Some orange to reddish brown oxidation on basalt fragments.	**Tb 4**	Note: weathered, amygdaloidal basalt.

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Drilling Method: Air Rotary	**Machine: Schramm** T130XD RIG T25	**Sampling Method:** Grab
Ground Elevation: 6885.55		**Total Depth:** 1175 ft bgs
Driller: H. Waddell, K. Keller, R. Wall, J. Allen	**Site Geologists:** T. Klepfer, B. Lucero, G. Kinsman, S. Thomas, M. Whitson, D. Oshlo, D. Staires	

Depth (ft bgs)	**Lithology**	**Lithologic Symbol**	**Notes**
580–635	Aphanitic, nonvesicular to moderately vesicular dense basalt and amygdaloidal basalt, gray (2.5Y5/1) to very dark gray (2.5Y3/1) with trace to some pumice and traces of intermediate composition volcanic lithic fragments and quartz and sanidine crystals. Basalt contains notable phenocrysts of olivine and plagioclase feldspar as well as abundant clay-infilled vessicles. +10F: 95-100% basalt fragments, 0-5% clay and lithic fragments, 0-trace% pumice fragments. +35F: 90-98% basalt fragments, 2-5% clay and lithic fragments, 2-5% pumice fragments, trace quartz and sanidine crystals. Abundant red to reddish brown oxidation on basalt-basaltic andesite fragments.	**Tb 4**	
635–650	Aphanitic, non to slightly vesicular basalt, pinkish gray (7.5YR7/2) to light brown (7.5YR6/4) with abundant pumice fragments, traces of intermediate composition volcanic lithic fragments, and traces of quartz and sanidine crystals. Basalt contains notable phenocrysts of olivine and plagioclase feldspar, partially clay-infilled vesicles, and abundant orange-red orange oxidation. +10F: 20-75% basalt fragments, 2-5% clay and lithic fragments, 25-75% pumice fragments. +35F: 40-70% basalt fragments, 2-5% clay and lithic fragments, 40-65% pumice fragments, 5-7% quartz and sanidine crystals.	**Tb 4**	
650–735	Aphanitic, nonvesicular to slightly vesicular dense basalt, gray (2.5Y5/1) to very dark gray (2.5Y3/1) with none to some pumice and none to traces of intermediate composition volcanic lithic fragments and quartz and sanidine crystals. Basalt contains notable phenocrysts of olivine and plagioclase feldspar. +10F: 95-100% basalt fragments, 0-3% clay and lithic fragments, 0-5% pumice fragments. +35F: 90-98% basalt fragments, trace-5% clay and lithic fragments, trace-5% pumice fragments, none to trace quartz and sanidine crystals. Abundant red to reddish brown oxidation on basalt-basaltic andesite fragments.	**Tb 4**	
735–740	Aphanitic, nonvesicular to slightly vesicular basalt, gray (2.5Y5/1) to light brown (7.5YR6/3) with abundant pumice fragments, trace of intermediate composition volcanic lithic fragments, and trace quartz and sanidine crystals. +10F: 65% basalt fragments, 0-3% clay and lithic fragments, 35% pumice fragments, trace quartz and sanidine crystals. +35F: 70% basalt fragments, 5% clay and lithic fragments, 25% pumice fragments, trace quartz and sanidine crystals. Abundant red to reddish brown oxidation on basalt-basaltic andesite fragments.	**Tb 4**	
740–745	No cuttings were returned in this interval.		

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Drilling Method: Air Rotary	**Machine: Schramm** T130XD RIG T25	**Sampling Method:** Grab
Ground Elevation: 6885.55		**Total Depth:** 1175 ft bgs
Driller: H. Waddell, K. Keller, R. Wall, J. Allen	**Site Geologists:** T. Klepfer, B. Lucero, G. Kinsman, S. Thomas, M. Whitson, D. Oshlo, D. Staires	

Depth (ft bgs)	**Lithology**	**Lithologic Symbol**	**Notes**
745–760	Aphanitic, nonvesicular to slightly vesicular basalt and scoria, gray (2.5Y5/1) to very dark gray (2.5Y3/1) with trace to some pumice, traces of intermediate composition volcanic lithic fragments, and quartz and sanidine crystals. Basalt contains partially clay-infilled vessicles. +10F: 85-95% basalt fragments, 0-5% clay and lithic fragments, 5-10% pumice fragments. +35F: 80-95% basalt fragments, 2-5% clay and lithic fragments, 5-15% pumice fragments, trace quartz and sanidine crystals. Abundant red to dark reddish brown oxidation on basalt-basaltic andesite fragments.	**Tb 4**	
760–770	Aphanitic, nonvesicular basalt with minor scoria, gray (2.5Y5/1) to light brown (7.5YR6/3) with abundant pumice, some intermediate composition volcanic lithic fragments and, trace quartz and sanidine crystals. +10F: 35-65% basalt fragments, 2-5% clay and lithic fragments, 30-65% pumice fragments. +35F: 50-75% basalt fragments, 2-5% clay and lithic fragments, 25-50% pumice fragments, trace quartz and sanidine crystals. Abundant red to dark reddish brown oxidation on basalt-basaltic andesite fragments and pumice fragments.	**Tb 4**	
770–810	Aphanitic, nonvesicular dense basalt, gray (2.5Y5/1) to very dark gray (2.5Y3/1) with none to trace pumice fragments and none to trace intermediate composition volcanic lithic fragments. +10F: 95-100% basalt fragments, 0-5% clay and lithic fragments, 0-trace% pumice fragments. +35F: 90-98% basalt fragments, 2-5% clay and lithic fragments, 2-5% pumice fragments, trace quartz and sanidine crystals. Some red to dark reddish brown oxidation on basalt-basaltic andesite fragments.	**Tb 4**	
810–825	Aphanitic, nonvesicular basalt, gray (2.5Y5/1) to light brown (7.5YR6/3) with abundant pumice, some intermediate composition volcanic lithic fragments, trace quartz and sanidine crystals. +10F: 65-75% basalt fragments, 2-5% clay and lithic fragments, 5-15% pumice fragments. +35F: 70-95% basalt fragments, 2-5% clay and lithic fragments, 5-15% pumice fragments, trace quartz and sanidine crystals. Trace red to dark reddish brown oxidation on basalt-basaltic andesite fragments.	**Tb 4**	

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Drilling Method: Air Rotary	**Machine: Schramm** T130XD RIG T25	**Sampling Method:** Grab
Ground Elevation: 6885.55		**Total Depth:** 1175 ft bgs
Driller: H. Waddell, K. Keller, R. Wall, J. Allen	**Site Geologists:** T. Klepfer, B. Lucero, G. Kinsman, S. Thomas, M. Whitson, D. Oshlo, D. Staires	

Depth (ft bgs)	**Lithology**	**Lithologic Symbol**	**Notes**
825–870	Aphanitic, nonvesicular basalt, gray (2.5Y5/1) to very dark gray (2.5Y3/1) with none to trace pumice fragments and none to trace intermediate composition volcanic lithic fragments. Basalt contains notable phenocrysts of olivine and plagioclase feldspar. +10F: 95-100% basalt fragments, 0-5% clay and lithic fragments, 0-trace% pumice fragments. +35F: 90-98% basalt fragments, 2-5% clay and lithic fragments, 2-5% pumice fragments, trace quartz and sanidine crystals. Some red to dark reddish brown oxidation on basalt-basaltic andesite fragments.	**Tb 4**	
870–880	Aphanitic, nonvesicular dense basalt, gray (2.5Y5/1) to light brown (7.5YR6/3) with abundant pumice, some intermediate composition volcanic lithic fragments, and trace quartz and sanidine crystals. +10F: 65-70% basalt fragments, 2-5% clay and lithic fragments, 5-20% pumice fragments. +35F: 70-85% basalt fragments, 2-5% clay and lithic fragments, 15-30% pumice fragments, trace quartz and sanidine crystals. Trace red to dark reddish brown oxidation on basalt-basalt fragments.	**Tb 4**	
880–885	Aphanitic, nonvesicular dense basalt, gray (2.5Y5/1) to very dark gray (2.5Y3/1) with trace pumice fragments and trace intermediate composition volcanic lithic fragments. +10F: 100% basalt fragments, 0% clay and lithic fragments, trace pumice fragments. +35F: 95% basalt fragments, 2% clay and lithic fragments, 3% pumice fragments, trace quartz and sanidine crystals.	**Tb 4**	
885–915	Aphanitic, nonvesicular dense basalt, gray (2.5Y5/1) to very dark gray (2.5Y3/1) with trace-some pumice fragments and trace-some intermediate composition volcanic lithic fragments. Basalt contains notable phenocrysts of olivine and plagioclase feldspar. +10F: 95-97% basalt fragments, 2-5% clay and lithic fragments, 2-7% pumice fragments. +35F: 90-95% basalt fragments, 2-10% clay and lithic fragments, 2-10% pumice fragments, trace quartz and sanidine crystals.	**Tb 4**	
915–920	No cuttings were returned in this interval.		
920–925	Aphanitic, nonvesicular basalt, light gray (2.5Y7/1) to gray (2.5Y6/1) with abundant pumice fragments and trace intermediate composition volcanic lithic fragments. Basalt contains notable phenocrysts of olivine and plagioclase. +10F: 15% basalt fragments, trace lithic fragments, 85% pumice fragments. +35F: 25% basalt fragments, trace lithic fragments, 75% pumice fragments, trace quartz and sanidine crystals. Trace red to dark reddish brown oxidation on basalt-basalt fragments.	**Tb 4**	Note: Abundant pumice.

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Drilling Company: Layne Christensen Co.	**Start Date/Time:** 1/9/10 1021	**End Date/Time:** 2/6/10 1500
Drilling Method: Air Rotary	**Machine: Schramm** T130XD RIG T25	**Sampling Method:** Grab
Ground Elevation: 6885.55		**Total Depth:** 1175 ft bgs
Driller: H. Waddell, K. Keller, R. Wall, J. Allen	**Site Geologists:** T. Klepfer, B. Lucero, G. Kinsman, S. Thomas, M. Whitson, D. Oshlo, D. Staires	

Depth (ft bgs)	Lithology	Lithologic Symbol	Notes
925–940	**PUYE FORMATION:** Silt to silty-clay (ML), gray (GLEY6/N) to very dark gray (GLEY3/N). Note: No 10F and 35F fraction.	**Tpf (lacustrine facies)**	Note: The interval between 925 and 980 resembles the description of sand, silt, and clays as well as well-rounded riverine gravels of the Puye Formation lacustrine facies.
940–945	Silt (ML) with vitric pumice fragments, minor intermediate volcanic lithic fragments and quartz crystals, gray (GLEY6/N) to very dark gray (GLEY3/N). Note: No 10F and 35F fraction.	**Tpf (lacustrine facies)**	
945–955	Silt to silty-clay (ML), gray (GLEY6/N) to very dark gray (GLEY3/N). Note: No 10F and 35F fraction.	**Tpf (lacustrine facies)**	
955–965	Silty gravels (GM-GC) in clay to silty clay matrix, brown (10YR4/3) to dark brown (10YR3/3), moderately sorted, subrounded-rounded. WR: Intermediate composition volcanic lithic fragments, pumice fragments, and silty claystone. +10F: 20-25% pumice fragments, 30-35% intermediate composition volcanic lithic fragments, 45-55% silty claystone. +35F: 10-15% pumice, 20-25% volcanic lithic fragments, 60-70% silty claystone. Moderately to highly weathered fragments.	**Tpf (lacustrine facies)**	Note: Well-rounded riverine type gravels.
965–970	Gravels (GC) in clay matrix, light brown (7.5YR6/3) to reddish brown (5YR5/3), moderately sorted, rounded. WR: Intermediate composition volcanic lithic fragments, pumice fragments, and silty claystone. +10F: 20-25% pumice fragments, 30-35% intermediate composition volcanic lithic fragments, 45-55% silty claystone. +35F: 10-15% pumice, 20-25% volcanic lithic fragments, 60-70% silty claystone. Moderately to highly weathered fragments.	**Tpf (lacustrine facies)**	Note: Well-rounded riverine type gravels.
970–980	Clay (CH-CL), light brown (7.5YR6/3) to reddish brown (5YR5/3). Note: No 10F and 35F fraction for this interval.	**Tpf (lacustrine facies)**	

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Drilling Method: Air Rotary	**Machine: Schramm** T130XD RIG T25	**Sampling Method:** Grab
Ground Elevation: 6885.55		**Total Depth:** 1175 ft bgs
Driller: H. Waddell, K. Keller, R. Wall, J. Allen	**Site Geologists:** T. Klepfer, B. Lucero, G. Kinsman, S. Thomas, M. Whitson, D. Oshlo, D. Staires	

Depth (ft bgs)	**Lithology**	**Lithologic Symbol**	**Notes**
980–985	Volcaniclastic sediments, moderately sorted, sub-angular to sub-rounded gravels (GC) in clay matrix, light brown (7.5YR6/3) to black (7.5YR2.5/1). WR: Intermediate volcanic lithic fragments (dacite), and silty claystone. +10F: 40-45% intermediate composition volcanic lithic fragments, 45-55% silty claystone. +35F: 20-25% volcanic lithic fragments, 60-70% silty claystone. Moderately to highly weathered fragments.	**Tpf**	Note: Contact between lacustrine clay facies and coarser gravels of Tpf appears to occur within this interval.
985–1000	Volcaniclastic sediments, moderately to poorly sorted, sub-angular to sub-rounded silty gravels (GM), gray (7.5YR5/1) to black (7.5YR2.5/1). WR: Intermediate volcanic lithic fragments (dacite), and silty claystone. +10F: 65-70% intermediate composition volcanic lithic fragments, 30-35% silty claystone. +35F: 65-70% volcanic lithic fragments, 30-45% silty claystone. Moderately to highly weathered fragments.	**Tpf**	
1000–1005	Volcaniclastic sediments, poorly sorted, well graded coarse sands and gravels (GW), subangular to subrounded, silty clay coating on gravel, grey (5YR5/1) to reddish gray (5YR5/2). +10F: 100% aphanitic and aphanitic-porphyritic, mafic to intermediate volcanics (up to 10mm). +35F: 99% volcanic lithic fragments, trace quartz and sanidine crystals, and 1% tuff/pumice fragments. Abundant yellow brown to reddish brown oxidation on volcanic fragments.	**Tpf**	
1005–1025	Volcaniclastic sediments, poorly sorted, well graded coarse sands and gravels (GW) subangular to subrounded, silty clay coating on gravel, grey (5YR5/1) to reddish gray (5YR5/2). Trace to no quartz crystals. +10F: 100% aphanitic, phaneritic, and aphanitic-porphyritic mafic to intermediate volcanics (up to 15 mm). +35F: 100% volcanic lithic fragments, trace to no quartz and sanidine crystals, trace to no tuff/pumice fragments.	**Tpf**	
1025–1030	Volcaniclastic sediments, poorly sorted, well graded coarse sands and gravels (GW) subangular to subrounded, silt and sand coating on gravels, grey (5YR5/1) to reddish gray (5YR5/2). Trace quartz crystals. +10F: 100% aphanitic, phaneritic, and aphanitic-porphyritic mafic to intermediate volcanics (up to 10mm). +35F: 65% volcanic lithic fragments, 35% quartz and sanidine crystals with trace tuff/pumice fragments.	**Tpf**	

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Drilling Company: Layne Christensen Co.	**Start Date/Time:** 1/9/10 1021	**End Date/Time:** 2/6/10 1500
Drilling Method: Air Rotary	**Machine: Schramm** T130XD RIG T25	**Sampling Method:** Grab
Ground Elevation: 6885.55		**Total Depth:** 1175 ft bgs
Driller: H. Waddell, K. Keller, R. Wall, J. Allen	**Site Geologists:** T. Klepfer, B. Lucero, G. Kinsman, S. Thomas, M. Whitson, D. Oshlo, D. Staires	

Depth (ft bgs)	**Lithology**	**Lithologic Symbol**	**Notes**
1030–1105	Volcaniclastic sediments, poorly sorted, well graded coarse sands and gravels (GW) subangular to subrounded, silty clay coating on gravels, grey (5YR5/1) to reddish gray (5YR5/2). Trace to no quartz crystals and trace to no pumice fragments. +10F: 100% aphanitic, phaneritic, and aphanitic-porphyritic mafic to intermediate volcanics (dacite, up to 15 mm), trace to no pumice fragments. +35F: 100% volcanic lithic fragments, trace to no quartz and sanidine crystals, trace to no tuff/pumice fragments. Some yellow brown to reddish brown oxidation on volcanic fragments.	**Tpf**	
1105–1115	Volcaniclastic sediments, poorly sorted, well graded coarse sands and gravels (GW) subangular to subrounded, silty clay and sandy coating on gravels, grey (5YR5/1) to reddish gray (5YR5/2). Some pumice fragments and trace quartz and sanidine crystals. +10F: 95-98% aphanitic, phaneritic, and aphanitic-porphyritic mafic to intermediate volcanics (dacite) (up to 5 mm), 2-5% pumice fragments. +35F: 75-85% volcanic lithic fragments, 5-10% quartz and sanidine crystals, 10-15% pumice fragments. Some yellow brown to reddish brown oxidation on volcanic fragments.	**Tpf**	
1115–1125	Volcaniclastic sediments, poorly sorted, well graded coarse sands and gravels (GW) subangular to subrounded, silty clay coating on gravels, grey (5YR5/1) to reddish gray (5YR5/2). Trace to no quartz crystals and trace to no pumice fragments. +10F: 100% aphanitic, phaneritic, and aphanitic-porphyritic mafic to intermediate volcanics (dacite) (up to 15 mm). +35F: 100% volcanic lithic fragments, trace to no quartz and sanidine crystals, trace to no tuff/pumice fragments. Some yellow brown to reddish brown oxidation on volcanic fragments.	**Tpf**	
1125–1130	Volcaniclastic sediments, poorly sorted, well graded coarse sands and gravels (GW) subangular to subrounded, silty clay and sandy coating on gravels, grey (5YR5/1) to reddish gray (5YR5/2). Some pumice fragments and trace quartz and sanidine crystals. +10F: 100% aphanitic, phaneritic, and aphanitic-porphyritic mafic to intermediate volcanics (up to 5 mm), trace quartz and sanidine crystals. +35F: 80% volcanic lithic fragments, 12% quartz and sanidine crystals, 8% pumice fragments. Some yellow brown to reddish brown oxidation on volcanic fragments.	**Tpf**	

Borehole Identification (ID): R-52	**Technical Area (TA):** 54	**Page:** 18 of 18
Drilling Company: Layne Christensen Co.	**Start Date/Time:** 1/9/10 1021	**End Date/Time:** 2/6/10 1500
Drilling Method: Air Rotary	**Machine: Schramm** T130XD RIG T25	**Sampling Method:** Grab
Ground Elevation: 6885.55		**Total Depth:** 1175 ft bgs
Driller: H. Waddell, K. Keller, R. Wall, J. Allen	**Site Geologists:** T. Klepfer, B. Lucero, G. Kinsman, S. Thomas, M. Whitson, D. Oshlo, D. Staires	

Depth (ft bgs)	**Lithology**	**Lithologic Symbol**	**Notes**
1130–1175	Volcaniclastic sediments, poorly sorted, well graded coarse sands and gravels (GW) subangular to subrounded, silty clay coating on gravels, gray (5YR5/1) to reddish gray (5YR5/2). Trace to no quartz crystals and trace to no pumice fragments. +10F: 100% aphanitic, phaneritic, and aphanitic-porphyritic mafic to intermediate volcanics (dacite) (up to 15 mm) including andesite and dacite. +35F: 100% volcanic lithic fragments, trace to no quartz and sanidine crystals, trace to no tuff/pumice fragments. Some yellow brown to reddish brown oxidation on volcanic fragments.	**Tpf**	End of borehole at 1175 ft bgs.

Abbreviations

7.5YR7/2 = Munsell soil color notation where hue, value, and chroma are expressed (e.g., hue=10YR, value=6, and chroma=3)

75% crystals = percentage of material in sieve sample fraction

bgs = below ground surface

ft = foot

CL = Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays

CH = Inorganic clays of high plasticity

GC = Clayey gravels, poorly graded gravel-sand-clay mixtures

GW = Well graded gravels, gravel-sand mixtures, little or no fines

GM = Silty gravels, poorly graded gravel-sand-silt mixtures

ML = Inorganic silts and very fine sands

SW = Well graded sands, gravelly sands, little or no fines

Qal = Quaternary Alluvium

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

Qbt 1v = Unit 1v of the Tshirege Member of the Bandelier Tuff

Qbt 1g = Unit 1g of the Tshirege Member of the Bandelier Tuff

Qct = Cerro Toledo Interval

Qbo = Otowi Member of the Bandelier Tuff

Qbog = Guaje Pumice Bed of the Otowi Member of the Bandelier Tuff

Tb4 = Cerros del Rio Volcanic Rocks

Tpf = Puye Formation

WR = whole rock

+10F = plus No. 10 sieve sample fraction

+35F = plus No. 35 sieve sample fraction

Appendix B

Groundwater Analytical Results

B-1.0 SAMPLING AND ANALYSIS OF GROUNDWATER AT R-52

A total of nine groundwater-screening samples were collected during drilling and development at well R-52. Three groundwater-screening samples were collected from the R-52 borehole at 916 ft (GW52-10-11189), 1054 ft (GW52-10-11182), and 1174.5 ft (GW52-10-11849) below ground surface (bgs). These samples were analyzed at an off-site laboratory for high explosive (HE) compounds, volatile organic compounds (VOCs) and low-level tritium (LH3). Los Alamos National Laboratory's (LANL's or the Laboratory's) Earth and Environmental Sciences Group 14 (EES-14) also analyzed aliquots of the samples for metals and anions, including perchlorate.

Six groundwater-screening samples were collected from well R-52 during development. Three samples (GW52-10-11184, GW52-10-11185, and GW52-10-11188) were collected from the upper screened interval between 1035.2 and 1055.7 ft bgs, and three samples (GW52-10-15463, GW52-10-15464, and GW52-10-15465) were collected from the lower screened interval between 1107.0 and 1117.0 ft bgs. Samples collected during development were analyzed for total organic carbon (TOC); samples GW52-10-15465 and GW52-10-11188 were also analyzed for metals, cations and anions, including perchlorate.

B-1.1 EES-14 Analytical Techniques

Groundwater samples were filtered (0.45-µm membranes) before preservation and chemical analyses. Samples were acidified at the EES-14 wet chemistry laboratory with analytical-grade nitric acid to a pH of 2.0 or less for metal and major cation analyses.

Groundwater samples were analyzed using techniques specified by the U.S. Environmental Protection Agency (EPA) methods for water analyses. Ion chromatography (EPA Method 300, revision 2.1) was the analytical method for bromide, chloride, fluoride, nitrate, nitrite, oxalate, perchlorate, phosphate, and sulfate. The instrument detection limit for perchlorate was 0.005 ppm in borehole water samples collected from R-52 (EPA Method 314.0, revision 1).

Inductively coupled (argon) plasma optical emission spectroscopy (EPA Method 200.7, revision 4.4) was used for analyses of dissolved aluminum, barium, boron, calcium, total chromium, iron, lithium, magnesium, manganese, potassium, silica, sodium, strontium, titanium, and zinc. Dissolved aluminum, antimony, arsenic, barium, beryllium, boron, cadmium, cesium, chromium, cobalt, copper, iron, lead, lithium, manganese, mercury, molybdenum, nickel, rubidium, selenium, silver, thallium, thorium, tin, vanadium, uranium, and zinc were analyzed by inductively coupled (argon) plasma mass spectrometry (EPA Method 200.8, revision 5.4). For metals analyzed by both techniques, the lower value is reported in the analytical results table (Table B-1.3-2).

Total carbonate alkalinity (EPA Method 310.1) was measured using standard titration techniques. Analyses of TOC were performed on groundwater-screening samples collected during development following EPA Method 415.1. Borehole samples were not analyzed for TOC because of potential sample matrix interference and the possible presence of drilling fluids.

B-1.2 Field Parameters

B-1.2.1 Well Development

Water samples were drawn from the pump discharge line into sealed containers, and field parameters were measured using a YSI, Inc. multimeter. Results of field parameters, consisting of pH, temperature, dissolved oxygen (DO), oxidation-reduction potential (ORP), specific conductance, and turbidity measured during development at well R-52, are provided in Table B-1.2-1.

Upper Screen

Measurements of pH and temperature varied from 7.9 to 8.5 and from 14.3 to 22.3°C, respectively, in groundwater pumped from the upper screen during development of well R-52. Concentrations of DO ranged from 4.5 to 1.0 mg/L. Corrected Eh values determined from field ORP measurements varied from 251.2 to 320.3 millivolts (mV) (Table B-1.2-1). Two temperature-dependent correction factors were used to calculate Eh values from field ORP measurements. These factors were based on an Ag/AgCl, KCl-saturated filling solution contained in the ORP electrode. The correction factors are 208.9 and 203.9 mV at 15ºC and 20ºC, respectively. Corrected Eh values, in combination with measured DO concentrations at the upper screen, are considered to be generally reliable and representative of the known relatively oxidizing conditions of the regional aquifer beneath the Pajarito Plateau. Specific conductance varied from 118 to 146 microsiemens per centimeter (μS/cm), and turbidity ranged from 23.8 nephelometric turbidity units (NTU) at the beginning of development to 0.2 NTU at the end (Table B-1.2-1). The final measurements for the other parameters at the end of development were pH 8.0, temperature 21.9°C, and specific conductance 137 μS/cm.

Lower Screen

Measurements of pH and temperature varied from 5.2 to 12.2 and from 18.9 to 20.5°C, respectively, in groundwater pumped from the lower screen during development of well R-52. The regional aquifer has background pH values that range from 6.43 to 8.96 with a median value of 7.85 (LANL 2007, 095817). Measured pH values less than 6.5 and greater than 8.5 are not considered to be reliable, based on previous pH measurements from groundwater samples collected from the regional aquifer. Concentrations of DO varied from 1.1 to 3.2 mg/L during development of the lower screen. Corrected Eh values determined from field ORP measurements varied from 154.5 to 209.6 mV during development of the lower screen at well R-52; the majority of ORP measurements were negative during development of the lower screen, in contrast to the much higher and positive values recorded during aquifer testing (see section B-1.2.2), indicating that the ORP meter was not functioning properly. Measurements of specific conductance varied from 108 to 146 μS/cm, and turbidity values varied from 117 to 0.0 NTU (Table B-1.2-1). Approximately half of the turbidity measurements recorded during development of the lower screen were 0.0 NTU, indicating that the turbidity meter was malfunctioning during development; however, the final turbidity recorded at the end of the 24-h aquifer test on April 23 was 1.9. The final measurements for the other water quality parameters at the end of development were temperature 20.0°C, specific conductance 108 μS/cm, and pH 10.7. The final pH at the end of the 24-h aquifer test was 7.9.

B-1.2.2 Aquifer Testing

Upper Screen

Measurements of pH and temperature slightly varied from 7.8 to 8.2 and from 18.0°C to 21.3°C, respectively, in groundwater pumped from the upper screen during aquifer testing. Concentrations of DO decreased from 3.6 to 0.9 mg/L. Corrected Eh values determined from field ORP measurements varied from 315.9 to 344.8 mV (Table B-1.2-1). Specific conductance varied from 126 to 145 μS/cm, and turbidity values varied from 252.2 to 4.0 NTU during aquifer testing.

Lower Screen

Measurements of pH and temperature varied from 7.7 to 8.1 and from 14.7°C to 22.1°C, respectively, in groundwater pumped from the lower screen during aquifer testing. Concentrations of DO varied from 11.7 to 1.0 mg/L; DO values greater than 7 mg/L are considered unreliable, based on measured lower screen groundwater temperatures. Corrected Eh values determined from field ORP measurements varied from 307.6 to 356.7 mV (Table B-1.2-1). Specific conductance varied from 110 to 139 μS/cm, and turbidity varied from 0.8 to 49.4 NTU during development (Table B-1.2-1).

B-1.3 Analytical Results for Groundwater-Screening Samples

Analytical results from the offsite laboratories and from LANL EES-14 are presented below. Where available, analytical results for well R-52 collected only during well development are screened against background concentrations developed for the Laboratory as a whole (LANL 2007, 095817). It should be noted that because of localized variations in geochemistry, background concentrations for the area upgradient of well R-52 may vary.

B-1.3.1 VOCs, HE, and LH3

VOC, HE, and LH3 analytical results are presented in Table B-1.3-1. Two VOCs, acetone, and 2-butanone were detected at estimated concentrations of 4.98 and 1.56 ppb, respectively, in borehole sample GW52-10-11182 from 1054 ft bgs. VOCs were not detected in the two other borehole groundwater samples from R-52. HE compounds were not detected in any of the borehole water samples. Tritium was reported at a concentration of 2.11 tritium units (6.8 pCi/L) in sample GW52-10-11189 from 916 ft bgs but was not detected in samples GW52-10-11182 and GW52-10-11849.

B-1.3.2 Cations, Anions, Perchlorate, and Metals

EES-14 analytical results for cations, anions, and metals from the three borehole samples and the two well development samples (GW52-10-15465 and GW52-10-11188) are provided in Table B-1.3-2. Additionally, off-site laboratory analyses for metals in sample GW52-10-11189 are shown in Table B-1.3-1. The filtered-borehole samples [GW52-10-11189, GW52-10-11182, and GW52-10-11849] consisted of disaggregated colloidal aquifer material, drilling material, water used during drilling, and native groundwater.

Key anions results from the borehole and well development samples are the following:

- Dissolved concentrations of fluoride ranged from 0.38 to 1.02 ppm in the three borehole water samples collected during drilling of R-52. Two groundwater-screening samples collected from the upper and lower screens during development contained 0.20 and 0.30 ppm of dissolved fluoride, respectively. Median and maximum background concentrations for dissolved fluoride in the regional aquifer are 0.35 and 0.57 ppm, respectively. (LANL 2007, 095817).
- Dissolved concentrations of nitrate(N) ranged from 0.09 to 0.59 ppm in the three borehole water samples collected during drilling of R-52 (Table B-1.3-2). Concentrations of nitrate(N) were 0.33 and 0.55 ppm in groundwater-screening samples collected from the upper and lower screens, respectively, during development. The median background concentration for dissolved nitrate(N) in the regional aquifer is 0.31 ppm.
- Dissolved concentrations of sulfate ranged from 4.08 to 27.7 ppm in the borehole water samples (Table B-1.3-2). Groundwater-screening samples collected from the upper and lower screens contained 6.06 and 7.85 ppm of sulfate, respectively. The median background concentration for dissolved sulfate in the regional aquifer is 2.83 ppm (LANL 2007, 095817).
- Perchlorate was not detected in the water samples collected during drilling of well R-52 or in the well development samples.

The precision limits (analytical error) for major ions and trace elements were generally less than ±7%. Charge balance errors for total cations and anions for the borehole water and development sample ranged from −8% to +8% collected during drilling and development of R-52. The negative cation-anion charge balance values indicate excess anions for the filtered samples.

Select metals analytical results from the borehole and development samples are the following:

- Iron, manganese, and zinc concentrations from the development samples are elevated because a corroded carbon-steel discharge pipe was used during development. The sample collected from the upper screen at the end of development contained 0.29 ppm of dissolved iron, 0.044 ppm of dissolved manganese, and 0.066 ppm of dissolved zinc (Table B-1.3-2). The sample collected from the lower screen at the end of development contained 0.19 ppm of dissolved iron, 0.023 ppm of dissolved manganese, and 0.056 ppm of dissolved zinc. Median background concentrations for dissolved iron, manganese, and zinc in the regional aquifer are 0.01885, 0.001 and 0.00145 ppm, respectively (LANL 2007, 095817).
- Analytical results for the three borehole water samples show elevated concentrations of dissolved molybdenum (0.157, 0.014, and 0.005 ppm), suggesting that these samples contain a component of drilling lubricant used in drilling. The two samples collected from both the upper screen (GW52-10-11188) and lower screen (GW52-10-15465) during development at well R-52 contained only 0.002 ppm of dissolved molybdenum.
- Dissolved concentrations of boron ranged from 0.173 to 0.278 ppm in the three borehole water samples collected during drilling of R-52. In contrast, concentrations of dissolved boron decreased to 0.047 ppm in the upper screen and to 0.118 ppm in the lower screen at the end of development. The maximum background concentration for dissolved boron in the regional aquifer is 0.0516 ppm (LANL 2007, 095817).
- Dissolved concentrations of barium ranged from 0.509 to 1.047 ppm in borehole water samples collected during drilling of R-52. Concentrations of dissolved barium decreased to 0.262 ppm in the upper screen and to 0.433 ppm in the lower screen at the end of development of each screened interval. Maximum background concentration for dissolved barium in the regional aquifer is 0.115 mg/L (LANL 2007, 095817).
- Total dissolved concentrations of chromium were 0.002 and 0.004 ppm in the three borehole water samples (Table B.1-3-2). The concentration of total dissolved chromium was 0.002 ppm in development samples collected from the upper and lower screens at well R-52. The median and maximum concentrations of total dissolved chromium in the regional aquifer are 3.05 and 7.20 µg/L, respectively (LANL 2007, 095817).

B-1.3.3 Total Organic Carbon

TOC was detected at 0.30 mgC/L in one development sample from the lower screen but was not detected in the other two samples from the lower screen (Table B-1.3-3). TOC concentrations in the upper screen decreased from 0.52 to 0.26 mgC/L during development. The median background concentration of TOC is 0.34 mgC/L for regional aquifer groundwater (LANL 2007, 095817).

B-1.4 Summary

In summary, groundwater at well R-52 is relatively oxidizing, based on corrected positive Eh values and measurable concentrations of DO during well development and aquifer testing. Redox conditions based on corrected field ORP measurements at well R-52 are similar to other wells previously drilled in the Pajarito watershed, including R-21 and R-23. Two VOC compounds, acetone and 2-butanone, were reported in one borehole sample collected during drilling but were not detected in the other two borehole samples. Tritium was reported at 2.11 tritium units (6.8 pCi/L) in one borehole sample collected from 916 ft bgs but was not detected in the other two samples collected during drilling. Final TOC concentrations for the six well development samples were less than the target concentration of 2 mgC/L.

B-2.0 REFERENCE

The following list includes all documents cited in this appendix. Parenthetical information following each reference provides the author(s), publication date, and ER ID. This information is also included in text citations. ER IDs are assigned by the Environmental Programs Directorate's Records Processing Facility (RPF) and are used to locate the document at the RPF and, where applicable, in the master reference set.

Copies of the master reference set are maintained at the NMED Hazardous Waste Bureau and the 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), May 2007. "Groundwater Background Investigation Report, Revision 3," Los Alamos National Laboratory document LA-UR-07-2853, Los Alamos, New Mexico. (LANL 2007, 095817)

Table B-1.2-1
Purge Volumes and Associated Field Water-Quality Parameters during Well Development and Aquifer Testing at R-52

Date	Time	pH	Temp (°C)	DO (mg/L)	ORP, Eh[a] (mV)	Specific Conductivity (µS/cm)	Turbidity (NTU)	Purge Volume between Samples (gal.)	Cumulative Purge Volume (gal.)
Well Development – Composite Water from Both Screens									
04/08/10[c]	1335	n/r[b]	n/r	n/r	n/r	n/r	n/r	5.6	5.6
	1738	n/r	n/r	n/r	n/r	n/r	n/r	67.3	67.3
04/09/10[c]	0946	8.3	18.5	n/r	n/r	213	2753	129.0	196.3
	1118	n/r	n/r	n/r	n/r	n/r	n/r	44.9	241.2
Well Development – Lower Screen									
04/17/10[d]	1230	11.2	19.8	2.8	−49.0, 154.9	118	117	557.4	798.6
	1300	9.2	20.3	2.9	−11.6, 192.3	114	83.5	410.4	1209.0
	1330	7.7	20.4	2.8	−8.9, 195.0	115	71.7	413.0	1622.0
	1400	5.5	20.2	3.1	−12.9, 191.6	110	51.4	417.6	2039.6
	1430	5.4	20.1	2.6	−12.9, 191.6	116	89.1	428.4	2468.0
	1500	5.2	20.0	2.5	−17.2, 186.7	120	55.4	459.6	2927.6
	1530	5.4	20.0	2.6	−19.4, 184.5	121	27.3	455.1	3382.7
	1600	9.9	20.2	2.6	−16.3, 187.6	122	24.9	445.9	3828.6
	1630	10.2	20.2	2.5	−18.1, 185.8	125	38.2	486.5	4315.1
	1700	10.2	20.2	2.5	−21.2, 182.7	126	38.2	463.0	4778.1
	1730	10.8	20.2	2.5	−22.1, 181.8	128	28.9	511.7	5289.8
	1800	10.9	20.0	2.4	−25.9, 178.0	129	25.0	528.8	5818.6
	1830	10.9	20.2	2.3	−22.0, 181.9	132	31.1	529.7	6348.3
	1900	11.2	20.0	2.3	−24.3, 197.6	132	30.4	440.6	6788.9
04/18/10[d]	0800	7.6	18.9	3.2	−49.4, 154.5	125	29.2	506.7	7295.6
	0830	7.5	19.6	3.1	5.7, 209.6	126	24.0	359.1	7654.7
	0900	12.2	19.5	2.9	−40.5, 163.4	146	16.7	405.4	8060.1
	0930	9.8	19.7	2.7	−2.8, 201.1	131	10.3	345.0	8405.1
	1000	10.2	19.9	2.7	−4.5, 199.4	131	8.0	369.5	8774.6
	1030	9.2	20.0	2.6	−2.9, 201.0	132	4.1	370.6	9145.2
	1100	8.6	20.1	2.6	−4.1, 199.8	132	4.3	371.8	9517.0
	1130	9.7	20.3	2.6	−3.8, 200.1	131	0.0	368.8	9885.8
	1400	11.0	19.2	2.5	−22.4, 181.5	125	0.0	1982.8	11,868.6
	1430	10.9	19.9	2.7	−11.4, 192.5	125	0.0	238.8	12,107.4
	1500	11.0	19.9	2.6	−11.8, 192.1	124	0.0	373.4	12,480.8
	1530	11.0	19.8	2.6	−11.0, 192.9	122	0.0	367.9	12,848.7
	1600	11.1	19.9	2.6	−11.1, 192.8	121	0.0	372.0	13,220.7
	1630	11.2	20.0	2.6	−8.9, 195.0	120	0.0	368.0	13,588.7
	1700	11.2	19.7	2.4	−11.7, 192.2	119	0.0	373.7	13,962.4
	1730	11.3	20.0	2.9	−4.2, 199.7	117	0.0	376.1	14,338.5

Table B-1.2-1 (continued)

Date	Time	pH	Temp (°C)	DO (mg/L)	ORP, Eh[a] (mV)	Specific Conductivity (µS/cm)	Turbidity (NTU)	Purge Volume between Samples (gal.)	Cumulative Purge Volume (gal.)
	1800	11.7	20.1	2.3	−12.6, 191.3	118	0.0	361.1	14,699.6
	1830	11.8	20.0	2.2	−12.8, 191.1	117	0.0	368.6	15,068.2
	1900	11.5	20.2	2.1	−9.4, 194.5	117	0.0	329.7	15,397.9
Well Development – Lower Screen									
04/19/10[d]	0800	7.0	19.3	2.5	−39.0, 164.9	117	2.6	300.0	15,697.9
	0830	7.7	19.9	2.1	−8.9, 195.0	113	0.0	354.8	16,052.7
	0900	8.4	19.9	1.9	−13.7, 190.2	113	0.2	358.2	16,410.9
	0930	8.7	20.2	2.0	−10.9, 193.0	113	0.0	361.0	16,771.9
	1000	9.4	20.2	1.9	−12.5, 191.4	113	0.0	360.0	17,131.9
	1030	9.6	20.5	1.9	−14.2, 189.7	113	0.0	372.7	17,504.6
	1100	9.7	20.5	1.8	−14.3, 189.6	112	0.0	358.5	17,863.1
	1130	6.4	20.5	1.7	−20.1, 183.8	112	0.0	355.6	18,218.7
	1200	9.7	20.3	1.7	−22.2, 181.7	112	0.0	359.6	18,578.3
	1430	10.1	19.7	1.8	−31.9, 172.0	109	0.0	1803.8	20,382.1
	1500	10.2	20.0	1.6	−29.0, 174.9	109	0.0	395.3	20,777.4
	1530	10.5	20.3	1.6	−27.6, 176.3	109	0.0	366.5	21,143.9
	1600	10.7	20.0	1.4	−29.8, 174.1	109	0.0	365.2	21,509.1
	1630	10.7	20.2	1.1	−26.8, 177.1	109	0.0	352.1	21,861.2
	1800	10.7	20.0	1.2	−30.3, 173.6	108	0.0	1077.9	22,939.1
Aquifer Testing – Lower Screen									
04/21/10[e]	0800	n/r	n/r	n/r	n/r	n/r	n/r	0	22,939.1
	0900	n/r	n/r	n/r	n/r	n/r	n/r	482.9	23,422.0
	1000	n/r	n/r	n/r	n/r	n/r	n/r	0	23,422.0
	1100	n/r	n/r	n/r	n/r	n/r	n/r	1142.3	24,564.3
04/22/10[f]	0800	n/r	n/r	n/r	n/r	n/r	n/r	0	24,564.3
	0808	8.0	14.7	10.3	117.9, 326.8	135	n/r	58.3	24,622.6
	0812	7.9	15.1	11.2	116.8, 320.7	135	n/r	31.3	24,653.9
	0822	7.9	18.1	11.7	116.0, 319.9	129	n/r	78.1	24,732.0
	0830	8.0	19.9	10.3	113.3, 317.2	132	n/r	62.6	24,794.6
	0900	8.0	20.2	8.4	103.7, 307.6	135	n/r	235.8	25,030.4
	0930	7.9	20.4	7.8	108.3, 312.2	134	n/r	235.7	25,266.1
	1000	7.9	20.4	5.8	107.2, 311.1	133	n/r	234.9	25,501.0
	1030	7.9	20.7	4.8	110.5, 314.4	136	5.5	235.7	25,736.7
	1100	8.0	21.0	3.8	110.1, 314.0	135	4.6	235.8	25,972.5
	1130	7.9	20.7	3.3	113.0, 317.9	136	5.0	235.5	26,208.0
	1200	8.0	21.1	3.5	112.4, 316.3	139	4.8	235.8	26,443.8
	1230	7.9	21.0	3.2	111.4, 315.3	134	6.3	236.0	26,679.8

Table B-1.2-1 (continued)

Date	Time	pH	Temp (°C)	DO (mg/L)	ORP, Eh[a] (mV)	Specific Conductivity (µS/cm)	Turbidity (NTU)	Purge Volume between Samples (gal.)	Cumulative Purge Volume (gal.)
	1300	8.0	21.3	2.9	111.5, 315.4	134	4.6	236.4	26,916.2
	1330	7.9	20.8	2.7	113.7, 317.6	136	4.4	236.6	27,152.8
	1400	8.0	20.5	2.7	114.3, 318.2	134	4.6	236.9	27,389.7
	1430	8.0	20.7	2.5	114.4, 318.3	133	4.7	237.0	27,626.7
	1500	7.9	20.7	2.7	116.4. 320.3	134	5.1	237.9	27,864.6
	1530	7.9	20.8	2.5	117.1, 321.0	137	3.7	238.6	28,103.2
	1600	7.9	20.7	2.2	118.6, 322.5	133	3.8	238.9	28,342.1
	1630	7.9	20.9	2.1	118.4, 322.3	137	3.7	238.7	28,580.8
	1700	7.9	20.7	2.0	120.1, 324.0	134	3.4	237.7	28,818.5
	1730	7.9	20.1	1.9	122.0, 325.9	137	3.7	237.6	29,056.1
	1800	7.9	20.0	1.8	122.5, 326.4	133	3.8	237.9	29,294.0
	1830	8.0	19.7	2.0	124.8, 328.7	133	3.4	238.8	29,532.8
	1900	7.9	19.7	1.9	125.6, 329.5	132	3.4	239.0	29,771.8
	1930	7.9	19.7	1.8	125.8, 329.7	133	3.1	241.5	30,013.3
	2000	7.6	19.6	1.7	126.2, 330.1	135	3.6	239.1	30,252.4
	2030	7.9	19.9	1.7	129.3, 333.2	134	4.6	238.6	30,491.0
	2100	7.9	19.6	1.6	129.8, 333.7	132	3.1	238.1	30,729.1
	2200	7.9	19.9	1.5	129.2, 330.1	134	3.5	487.0	31,216.1
	2230	8.0	20.0	1.7	127.5, 331.4	132	2.9	228.0	31,444.1
Aquifer Testing – Lower Screen									
04/22/10[f]	2300	8.0	20.0	1.6	128.8, 332.7	134	3.4	238.1	31,682.2
	2330	7.9	19.9	1.7	133.3, 337.2	132	1.5	237.9	31,920.1
	2400	8.0	20.1	1.6	131.1, 335.0	133	1.4	238.1	32,158.2
04/23/10[f]	0030	8.0	19.7	1.5	131.0, 334.9	136	0.8	239.3	32,397.5
	0100	7.9	19.5	1.6	135.0, 338.9	132	2.1	237.8	32,635.3
	0200	7.9	19.3	1.6	136.8, 340.7	135	1.4	478.1	33,113.4
	0230	7.9	19.7	1.6	136.4, 340.3	134	1.3	239.0	33,352.4
	0300	7.9	19.5	1.5	137.1, 341.0	135	1.5	238.9	33,591.3
	0330	7.9	19.4	1.6	137.8, 341.7	130	1.4	239.7	33,831.0
	0400	7.7	19.3	1.6	152.8, 356.7	133	1.5	238.7	34,069.7
	0430	7.9	19.3	1.5	141.4, 345.3	134	1.8	239.7	34,309.4
	0500	8.0	19.4	1.4	140.4, 344.3	134	1.8	238.3	34,547.7
	0530	8.0	19.7	1.5	141.3, 345.2	133	1.6	238.5	34,786.2
	0600	7.9	19.7	1.5	145.2, 349.1	131	1.4	238.3	35,024.5
	0630	8.0	19.4	1.5	143.9, 347.8	133	1.7	232.2	35,256.7
	0700	8.0	19.9	1.4	144.8, 348.7	130	1.7	235.3	35,492.0

Table B-1.2-1 (continued)

Date	Time	pH	Temp (°C)	DO (mg/L)	ORP, Eh[a] (mV)	Specific Conductivity (µS/cm)	Turbidity (NTU)	Purge Volume between Samples (gal.)	Cumulative Purge Volume (gal.)
	0730	7.9	20.4	1.4	147.6, 351.5	134	1.9	238.2	35,730.2
	0800	7.9	20.2	1.5	146.6, 350.5	133	1.9	238.2	35,968.4
05/04/10[g]	0701	8.0	15.1	4.2	142.6, 351.5	110	49.4	19.5	35,987.9
	0730	8.1	20.9	4.3	133.5, 337.4	129	9.5	562.5	36,550.4
	0800	8.1	21.1	3.0	119.5, 323.4	132	10.1	576.5	37,126.9
	0830	8.1	20.7	2.0	114.3, 318.2	127	10.0	578.9	37,705.8
	0900	8.0	21.3	1.8	124.7, 328.6	129	9.5	581.9	38,287.7
	0930	8.0	21.4	1.5	124.0, 325.9	131	7.9	582.2	38,869.9
	1000	8.1	21.6	1.4	118.5, 322.4	128	5.7	583.2	39,453.1
	1030	8.1	21.4	1.2	122.9, 326.8	126	6.3	592.5	40,045.6
	1100	8.0	21.8	1.1	111.7, 315.6	126	6.3	581.1	40,626.7
	1130	8.0	22.0	1.0	128.6, 332.5	128	6.1	593.1	41,219.8
	1200	8.1	22.1	1.1	126.1, 330.9	129	6.1	583.5	41,803.3
Well Development – Upper Screen									
04/09/10[c]	1444	n/r	n/r	n/r	n/r	n/r	n/r	5.61	41,808.9
	1645	n/r	n/r	n/r	n/r	n/r	n/r	56.1	41,865.0
04/10/10[c]	0809	n/r	n/r	n/r	n/r	n/r	n/r	67.3	41,932.3
	1430	n/r	n/r	n/r	n/r	n/r	n/r	174.7	42,107.0
04/26/10[d]	0850	n/r	n/r	n/r	n/r	n/r	n/r	0	42,107.0
	0930	7.9	18.4	4.5	116.4, 320.3	138	12.6	n/r	42,107.0
	1000	8.0	19.5	3.7	111.0, 314.9	143	17.9	140.2	42,247.2
	1030	8.0	20.8	3.1	108.7, 312.4	133	21.2	149.7	42,396.9
	1100	8.1	21.9	2.6	106.5, 310.4	143	23.8	163.9	42,560.8
	1130	8.0	22.0	2.5	109.2, 313.1	139	13.0	172.6	42,733.4
	1200	8.0	22.0	2.4	115.6, 319.5	144	7.8	173.4	42,906.8
	1230	8.0	22.2	2.3	109.9, 313.8	145	5.7	204.1	43,110.9
	1300	8.1	22.2	2.2	103.0, 306.9	141	5.9	139.3	43,250.2
	1330	8.0	21.1	2.9	92.8, 286.7	141	5.3	122.5	43,372.7
	1400	8.0	22.0	2.8	84.1, 288.0	137	4.8	103.7	43,476.4
	1430	7.9	21.8	2.6	88.0, 291.9	140	3.9	70.8	43,547.2
	1500	8.0	21.5	2.6	84.7, 288.6	135	3.2	129.2	43,676.4
	1530	8.1	21.5	2.3	74.9, 278,8	143	2.9	147.6	43,824.0
	1600	8.0	21.6	2.7	76.2, 280.1	145	2.7	154.0	43,978.0
	1630	8.0	21.6	2.7	77.2, 281.1	138	2.1	164.0	44,142.0
	1700	8.1	21.4	3.0	71.5, 275.4	146	1.5	143.6	44,285.6
	1730	8.0	21.3	2.8	71.8, 275.7	143	1.8	144.9	44,430.5
	1800	8.1	21.6	2.2	73.2, 277.1	139	1.7	139.0	44,569.5

Table B-1.2-1 (continued)

Date	Time	pH	Temp (°C)	DO (mg/L)	ORP, Eh[a] (mV)	Specific Conductivity (µS/cm)	Turbidity (NTU)	Purge Volume between Samples (gal.)	Cumulative Purge Volume (gal.)
04/27/10[d]	0730	n/r	n/r	n/r	n/r	n/r	n/r	0	44,569.5
	0800	8.5	14.3	1.7	90.7, 294.6	131	19.6	94.3	44,663.8
	0830	8.5	16.8	2.1	77.9, 281.8	118	6.4	145.0	44,808.8
	0900	8.2	18.9	2.7	71.5, 275.4	140	5.2	155.8	44,964.6
	0930	8.2	19.8	2.5	75.9, 279.8	140	4.2	149.2	45,113.8
	1000	8.1	20.1	2.6	72.6, 276.5	142	2.2	152.9	45,266.7
	1100	8.1	21.0	2.2	70.4, 274.3	136	0.9	316.2	45,582.9
	1200	8.1	20.9	2.2	59.1, 263.0	139	0.8	332.9	45,915.8
	1300	8.1	21.3	2.2	55.5, 259.4	138	1.3	329.7	46,245.5
	1400	8.1	21.4	1.7	55.0, 258.9	138	1.8	321.3	46,566.8
	1500	8.0	21.6	1.3	61.5, 265.4	133	1.3	335.4	46,902.2
	1600	8.0	21.9	1.4	64.7, 268.6	138	1.9	344.3	47,246.5
	1630	8.1	21.6	1.5	57.3, 261.2	137	1.5	167.0	47,413.5
Well Development – Upper Screen									
04/27/10[d]	1730	8.1	21.6	1.6	51.9, 255.8	138	1.4	318.6	47,732.1
	1830	8.0	21.4	1.2	47.3, 251.2	135	1.4	316.3	48,048.4
04/28/10[d]	0730	n/r	n/r	n/r	n/r	n/r	n/r	0	48,048.4
	0830	8.4	15.0	1.1	67.2, 276.1	125	2.9	285.2	48,333.6
	0930	8.4	20.1	1.3	81.0, 284.9	138	2.6	305.1	48,638.7
	1030	8.2	21.0	1.0	88.1, 292.0	137	1.9	320.4	48,959.1
	1130	8.2	21.2	1.0	88.7, 292.6	134	1.4	310.6	49,269.7
	1230	8.1	21.9	1.3	82.7, 286.6	140	1.2	326.5	49,596.2
	1330	8.1	22.1	1.6	83.6, 287.5	137	1.0	323.3	49,919.5
	1430	8.1	22.3	1.5	77.7, 281.6	132	0.8	321.5	50,241.0
	1530	8.1	22.3	1.6	77.9, 281.8	140	0.8	334.3	50,575.3
	1630	8.0	22.2	1.6	79.3, 283.2	141	0.8	314.5	50,889.8
	1730	8.0	21.9	1.6	68.0, 271.9	137	0.2	312.3	51,202.1
Aquifer Testing – Upper Screen									
04/30/10[e]	0800	n/r	n/r	n/r	n/r	n/r	n/r	0	51,202.1
	0900	n/r	n/r	n/r	n/r	n/r	n/r	252.0	51,454.1
	1000	n/r	n/r	n/r	n/r	n/r	n/r	0	51,454.1
	1100	n/r	n/r	n/r	n/r	n/r	n/r	252.2	51,706.3

Table B-1.2-1 (continued)

Date	Time	pH	Temp (°C)	DO (mg/L)	ORP, Eh[a] (mV)	Specific Conductivity (µS/cm)	Turbidity (NTU)	Purge Volume between Samples (gal.)	Cumulative Purge Volume (gal.)
05/01/10[f]	0800	n/r	n/r	n/r	n/r	n/r	n/r	0	51,706.3
	0900	8.2	20.9	3.6	112.0, 315.9	135	2.2	236.5	51,942.8
	1000	8.1	21.3	3.5	126.8, 330.7	138	1.7	210.5	52,153.3
	1100	8.0	21.1	3.0	124.3, 328.2	135	1.3	206.8	52,360.1
	1130	8.0	21.1	3.1	112.7, 316.6	128	1.2	105.3	52,465.4
	1200	8.0	20.7	2.9	116.5, 320.4	137	1.2	106.4	52,571.8
	1230	7.9	20.9	2.4	113.0, 316.9	132	1.0	105.8	52,677.6
	1300	8.0	20.2	2.0	119.3, 323.2	130	1.0	104.3	52,781.9
	1330	8.0	20.5	1.9	121.0, 324.9	129	0.7	109.3	52,891.2
	1400	8.0	20.5	1.7	128.7, 332.6	127	1.0	108.9	53,000.1
	1500	8.0	20.9	1.5	125.2, 329.1	137	1.0	218.3	53,218.4
	1530	8.0	20.7	1.7	126.3, 330.2	126	1.0	109.8	53,328.2
	1600	8.0	20.5	1.6	122.0, 325.9	133	0.8	110.4	53,438.6
	1630	8.0	21.0	1.3	128.0, 331.9	136	0.8	107.7	53,546.3
	1700	8.0	20.5	1.6	125.0, 328.9	127	1.0	113.1	53,659.4
	1730	8.0	20.8	1.5	127.4, 331.3	127	0.9	110.3	53,769.7
	1800	8.0	20.8	1.4	126.3, 330.2	129	1.0	111.0	53,880.7
	1830	8.0	20.7	1.4	121.4, 325.3	128	1.0	108.6	53,989.3
	1900	7.9	20.8	1.2	122.9, 326.8	127	0.7	115.0	54,104.3
	1930	8.0	20.8	1.2	122.9, 326.8	136	0.6	119.1	54,223.4
	2000	8.0	20.6	1.2	124.4, 328.3	139	0.5	105.6	54,329.0
	2030	7.9	20.6	1.3	125.8, 329.7	127	0.8	111.2	54,440.2
	2100	8.0	20.6	1.3	124.8, 328.7	127	0.4	111.5	54,551.7
	2130	8.0	20.6	1.2	124.9, 328.8	132	0.5	112.4	54,664.1
	2200	8.0	20.6	1.2	126.3, 330.2	137	1.0	112.2	54,776.3
	2230	7.9	20.5	1.4	127.2, 331.6	131	0.6	112.6	54,888.9
	2300	8.0	20.3	1.2	127.8, 331.7	135	0.6	101.9	54,990.8
	2330	8.0	18.0	1.6	128.8, 332.7	135	0.6	51.8	55,042.6

Table B-1.2-1 (continued)

Date	Time	pH	Temp (°C)	DO (mg/L)	ORP, Eh[a] (mV)	Specific Conductivity (µS/cm)	Turbidity (NTU)	Purge Volume between Samples (gal.)	Cumulative Purge Volume (gal.)
Aquifer Testing – Upper Screen									
05/02/10[f]	0500[h]	7.8	18.4	1.5	133.6, 337.5	145	4.0	165.7	55,208.3
	0530	8.0	20.3	1.3	127.4, 331.8	130	202.0	101.1	55,309.4
	0600	8.0	20.3	0.9	131.1, 335.0	133	153.0	102.4	55,411.8
	0630	8.0	20.3	0.9	134.5, 334.5	136	37.7	103.8	55,515.6
	0700	8.0	20.2	1.0	138.4, 342.3	139	12.4	98.9	55,614.5
	0730	8.0	20.6	0.9	140.9, 344.8	131	8.1	101.7	55,716.2
	0800	8.0	20.5	1.0	135.1, 339.0	132	6.3	104.8	55,821.0

[a] Eh (mV) is calculated from a Ag/AgCl saturated KCl electrode filling solution at 15ºC and 20ºC by adding temperature-sensitive correction factors of 208.9 mV and 203.9 mV, respectively.

[b] n/r = Not recorded.

[c] Bailing.

[d] Pumping.

[e] Step test.

[f] 24-h pumping test.

[g] Additional pumping.

[h] Shutdown from 2330 to 0500 to reinflate packer.

Table B-1.3-1
Off-Site Analytical Data

Lab Request Number	Sample ID	Analytical Suite Code	Analytical Method Code	Analyte Description	Lab Result	Unit	Validation Qualifier Code
10-1683	GW52-10-11182	HEXP	SW-846:8321A_MOD	2,4-Diamino-6-nitrotoluene	13	µg/L	U[a]
10-1683	GW52-10-11182	HEXP	SW-846:8321A_MOD	2,6-Diamino-4-nitrotoluene	13	µg/L	U
10-1683	GW52-10-11182	HEXP	SW-846:8321A_MOD	3,5-Dinitroaniline	13	µg/L	U
10-1683	GW52-10-11182	HEXP	SW-846:8321A_MOD	Amino-2,6-dinitrotoluene[4-]	3.25	µg/L	U
10-1683	GW52-10-11182	HEXP	SW-846:8321A_MOD	Amino-4,6-dinitrotoluene[2-]	3.25	µg/L	U
10-1683	GW52-10-11182	HEXP	SW-846:8321A_MOD	Dinitrobenzene[1,3-]	3.25	µg/L	U
10-1683	GW52-10-11182	HEXP	SW-846:8321A_MOD	Dinitrotoluene[2,4-]	3.25	µg/L	U
10-1683	GW52-10-11182	HEXP	SW-846:8321A_MOD	Dinitrotoluene[2,6-]	3.25	µg/L	U
10-1683	GW52-10-11182	HEXP	SW-846:8321A_MOD	HMX	3.25	µg/L	U
10-1683	GW52-10-11182	HEXP	SW-846:8321A_MOD	Nitrobenzene	3.25	µg/L	U
10-1683	GW52-10-11182	HEXP	SW-846:8321A_MOD	Nitrotoluene[2-]	3.25	µg/L	U
10-1683	GW52-10-11182	HEXP	SW-846:8321A_MOD	Nitrotoluene[3-]	3.25	µg/L	U
10-1683	GW52-10-11182	HEXP	SW-846:8321A_MOD	Nitrotoluene[4-]	6.49	µg/L	U
10-1683	GW52-10-11182	HEXP	SW-846:8321A_MOD	PETN	13	µg/L	U
10-1683	GW52-10-11182	HEXP	SW-846:8321A_MOD	RDX	3.25	µg/L	U
10-1683	GW52-10-11182	HEXP	SW-846:8321A_MOD	TATB	13	µg/L	U
10-1683	GW52-10-11182	HEXP	SW-846:8321A_MOD	Tetryl	6.49	µg/L	U
10-1683	GW52-10-11182	HEXP	SW-846:8321A_MOD	Trinitrobenzene[1,3,5-]	3.25	µg/L	U
10-1683	GW52-10-11182	HEXP	SW-846:8321A_MOD	Trinitrotoluene[2,4,6-]	3.25	µg/L	U
10-1683	GW52-10-11182	HEXP	SW-846:8321A_MOD	Tris (o-cresyl) phosphate	13	µg/L	U
10-1684	GW52-10-11182	LH3	Generic:Low_Level_Tritium	Tritium	0.08	TU[b]	U
10-1683	GW52-10-11182	VOC	SW-846:8260B	Acetone	4.98	µg/L	J-[c]
10-1683	GW52-10-11182	VOC	SW-846:8260B	Acetonitrile	25	µg/L	R[d]
10-1683	GW52-10-11182	VOC	SW-846:8260B	Acrolein	5	µg/L	R
10-1683	GW52-10-11182	VOC	SW-846:8260B	Acrylonitrile	5	µg/L	UJ[e]
10-1683	GW52-10-11182	VOC	SW-846:8260B	Benzene	1	µg/L	UJ
10-1683	GW52-10-11182	VOC	SW-846:8260B	Bromobenzene	1	µg/L	UJ
10-1683	GW52-10-11182	VOC	SW-846:8260B	Bromochloromethane	1	µg/L	UJ
10-1683	GW52-10-11182	VOC	SW-846:8260B	Bromodichloromethane	1	µg/L	UJ
10-1683	GW52-10-11182	VOC	SW-846:8260B	Bromoform	1	µg/L	UJ
10-1683	GW52-10-11182	VOC	SW-846:8260B	Bromomethane	1	µg/L	UJ
10-1683	GW52-10-11182	VOC	SW-846:8260B	Butanol[1-]	50	µg/L	UJ
10-1683	GW52-10-11182	VOC	SW-846:8260B	Butanone[2-]	1.56	µg/L	J-
10-1683	GW52-10-11182	VOC	SW-846:8260B	Butylbenzene[n-]	1	µg/L	UJ
10-1683	GW52-10-11182	VOC	SW-846:8260B	Butylbenzene[sec-]	1	µg/L	UJ
10-1683	GW52-10-11182	VOC	SW-846:8260B	Butylbenzene[tert-]	1	µg/L	UJ
10-1683	GW52-10-11182	VOC	SW-846:8260B	Carbon Disulfide	5	µg/L	UJ

Table B-1.3-1 (continued)

Lab Request Number	Sample ID	Analytical Suite Code	Analytical Method Code	Analyte Description	Lab Result	Unit	Validation Qualifier Code
10-1683	GW52-10-11182	VOC	SW-846:8260B	Chloro-1,3-butadiene[2-]	1	µg/L	UJ
10-1683	GW52-10-11182	VOC	SW-846:8260B	Chloro-1-propene[3-]	5	µg/L	UJ
10-1683	GW52-10-11182	VOC	SW-846:8260B	Chlorobenzene	1	µg/L	UJ
10-1683	GW52-10-11182	VOC	SW-846:8260B	Chlorodibromomethane	1	µg/L	UJ
10-1683	GW52-10-11182	VOC	SW-846:8260B	Chloroethane	1	µg/L	UJ
10-1683	GW52-10-11182	VOC	SW-846:8260B	Chloroform	1	µg/L	UJ
10-1683	GW52-10-11182	VOC	SW-846:8260B	Chloromethane	1	µg/L	UJ
10-1683	GW52-10-11182	VOC	SW-846:8260B	Chlorotoluene[2-]	1	µg/L	UJ
10-1683	GW52-10-11182	VOC	SW-846:8260B	Chlorotoluene[4-]	1	µg/L	UJ
10-1683	GW52-10-11182	VOC	SW-846:8260B	Dibromo-3-Chloropropane[1,2-]	1	µg/L	UJ
10-1683	GW52-10-11182	VOC	SW-846:8260B	Dibromoethane[1,2-]	1	µg/L	UJ
10-1683	GW52-10-11182	VOC	SW-846:8260B	Dibromomethane	1	µg/L	UJ
10-1683	GW52-10-11182	VOC	SW-846:8260B	Dichlorobenzene[1,2-]	1	µg/L	UJ
10-1683	GW52-10-11182	VOC	SW-846:8260B	Dichlorobenzene[1,3-]	1	µg/L	UJ
10-1683	GW52-10-11182	VOC	SW-846:8260B	Dichlorobenzene[1,4-]	1	µg/L	UJ
10-1683	GW52-10-11182	VOC	SW-846:8260B	Dichlorodifluoromethane	1	µg/L	UJ
10-1683	GW52-10-11182	VOC	SW-846:8260B	Dichloroethane[1,1-]	1	µg/L	UJ
10-1683	GW52-10-11182	VOC	SW-846:8260B	Dichloroethane[1,2-]	1	µg/L	UJ
10-1683	GW52-10-11182	VOC	SW-846:8260B	Dichloroethene[1,1-]	1	µg/L	UJ
10-1683	GW52-10-11182	VOC	SW-846:8260B	Dichloroethene[cis-1,2-]	1	µg/L	UJ
10-1683	GW52-10-11182	VOC	SW-846:8260B	Dichloroethene[trans-1,2-]	1	µg/L	UJ
10-1683	GW52-10-11182	VOC	SW-846:8260B	Dichloropropane[1,2-]	1	µg/L	UJ
10-1683	GW52-10-11182	VOC	SW-846:8260B	Dichloropropane[1,3-]	1	µg/L	UJ
10-1683	GW52-10-11182	VOC	SW-846:8260B	Dichloropropane[2,2-]	1	µg/L	UJ
10-1683	GW52-10-11182	VOC	SW-846:8260B	Dichloropropene[1,1-]	1	µg/L	UJ
10-1683	GW52-10-11182	VOC	SW-846:8260B	Dichloropropene[cis-1,3-]	1	µg/L	UJ
10-1683	GW52-10-11182	VOC	SW-846:8260B	Dichloropropene[trans-1,3-]	1	µg/L	UJ
10-1683	GW52-10-11182	VOC	SW-846:8260B	Diethyl Ether	1	µg/L	UJ
10-1683	GW52-10-11182	VOC	SW-846:8260B	Ethyl Methacrylate	5	µg/L	UJ
10-1683	GW52-10-11182	VOC	SW-846:8260B	Ethylbenzene	1	µg/L	UJ
10-1683	GW52-10-11182	VOC	SW-846:8260B	Hexachlorobutadiene	1	µg/L	UJ
10-1683	GW52-10-11182	VOC	SW-846:8260B	Hexanone[2-]	5	µg/L	UJ
10-1683	GW52-10-11182	VOC	SW-846:8260B	Iodomethane	5	µg/L	UJ
10-1683	GW52-10-11182	VOC	SW-846:8260B	Isobutyl alcohol	50	µg/L	R
10-1683	GW52-10-11182	VOC	SW-846:8260B	Isopropylbenzene	1	µg/L	UJ
10-1683	GW52-10-11182	VOC	SW-846:8260B	Isopropyltoluene[4-]	1	µg/L	UJ

Table B-1.3-1 (continued)

Lab Request Number	Sample ID	Analytical Suite Code	Analytical Method Code	Analyte Description	Lab Result	Unit	Validation Qualifier Code
10-1683	GW52-10-11182	VOC	SW-846:8260B	Methacrylonitrile	5	µg/L	UJ
10-1683	GW52-10-11182	VOC	SW-846:8260B	Methyl Methacrylate	5	µg/L	UJ
10-1683	GW52-10-11182	VOC	SW-846:8260B	Methyl tert-Butyl Ether	1	µg/L	UJ
10-1683	GW52-10-11182	VOC	SW-846:8260B	Methyl-2-pentanone[4-]	5	µg/L	UJ
10-1683	GW52-10-11182	VOC	SW-846:8260B	Methylene Chloride	10	µg/L	UJ
10-1683	GW52-10-11182	VOC	SW-846:8260B	Naphthalene	1	µg/L	UJ
10-1683	GW52-10-11182	VOC	SW-846:8260B	Propionitrile	5	µg/L	R
10-1683	GW52-10-11182	VOC	SW-846:8260B	Propylbenzene[1-]	1	µg/L	UJ
10-1683	GW52-10-11182	VOC	SW-846:8260B	Styrene	1	µg/L	UJ
10-1683	GW52-10-11182	VOC	SW-846:8260B	Tetrachloroethane[1,1,1,2-]	1	µg/L	UJ
10-1683	GW52-10-11182	VOC	SW-846:8260B	Tetrachloroethane[1,1,2,2-]	1	µg/L	UJ
10-1683	GW52-10-11182	VOC	SW-846:8260B	Tetrachloroethene	1	µg/L	UJ
10-1683	GW52-10-11182	VOC	SW-846:8260B	Toluene	1	µg/L	UJ
10-1683	GW52-10-11182	VOC	SW-846:8260B	Trichloro-1,2,2-trifluoroethane[1,1,2-]	5	µg/L	UJ
10-1683	GW52-10-11182	VOC	SW-846:8260B	Trichlorobenzene[1,2,3-]	1	µg/L	UJ
10-1683	GW52-10-11182	VOC	SW-846:8260B	Trichlorobenzene[1,2,4-]	1	µg/L	UJ
10-1683	GW52-10-11182	VOC	SW-846:8260B	Trichloroethane[1,1,1-]	1	µg/L	UJ
10-1683	GW52-10-11182	VOC	SW-846:8260B	Trichloroethane[1,1,2-]	1	µg/L	UJ
10-1683	GW52-10-11182	VOC	SW-846:8260B	Trichloroethene	1	µg/L	UJ
10-1683	GW52-10-11182	VOC	SW-846:8260B	Trichlorofluoromethane	1	µg/L	UJ
10-1683	GW52-10-11182	VOC	SW-846:8260B	Trichloropropane[1,2,3-]	1	µg/L	UJ
10-1683	GW52-10-11182	VOC	SW-846:8260B	Trimethylbenzene[1,2,4-]	1	µg/L	UJ
10-1683	GW52-10-11182	VOC	SW-846:8260B	Trimethylbenzene[1,3,5-]	1	µg/L	UJ
10-1683	GW52-10-11182	VOC	SW-846:8260B	Vinyl acetate	5	µg/L	UJ
10-1683	GW52-10-11182	VOC	SW-846:8260B	Vinyl Chloride	1	µg/L	UJ
10-1683	GW52-10-11182	VOC	SW-846:8260B	Xylene[1,2-]	1	µg/L	UJ
10-1683	GW52-10-11182	VOC	SW-846:8260B	Xylene[1,3-]+Xylene[1,4-]	2	µg/L	UJ
10-1683	GW52-10-11183	VOC	SW-846:8260B	Acetone	10	µg/L	U
10-1683	GW52-10-11183	VOC	SW-846:8260B	Acetonitrile	25	µg/L	R
10-1683	GW52-10-11183	VOC	SW-846:8260B	Acrolein	5	µg/L	U
10-1683	GW52-10-11183	VOC	SW-846:8260B	Acrylonitrile	5	µg/L	U
10-1683	GW52-10-11183	VOC	SW-846:8260B	Benzene	1	µg/L	U
10-1683	GW52-10-11183	VOC	SW-846:8260B	Bromobenzene	1	µg/L	U
10-1683	GW52-10-11183	VOC	SW-846:8260B	Bromochloromethane	1	µg/L	U
10-1683	GW52-10-11183	VOC	SW-846:8260B	Bromodichloromethane	1	µg/L	U
10-1683	GW52-10-11183	VOC	SW-846:8260B	Bromoform	1	µg/L	U

Table B-1.3-1 (continued)

Lab Request Number	Sample ID	Analytical Suite Code	Analytical Method Code	Analyte Description	Lab Result	Unit	Validation Qualifier Code
10-1683	GW52-10-11183	VOC	SW-846:8260B	Bromomethane	1	µg/L	U
10-1683	GW52-10-11183	VOC	SW-846:8260B	Butanol[1-]	50	µg/L	R
10-1683	GW52-10-11183	VOC	SW-846:8260B	Butanone[2-]	5	µg/L	U
10-1683	GW52-10-11183	VOC	SW-846:8260B	Butylbenzene[n-]	1	µg/L	U
10-1683	GW52-10-11183	VOC	SW-846:8260B	Butylbenzene[sec-]	1	µg/L	U
10-1683	GW52-10-11183	VOC	SW-846:8260B	Butylbenzene[tert-]	1	µg/L	U
10-1683	GW52-10-11183	VOC	SW-846:8260B	Carbon Disulfide	5	µg/L	U
10-1683	GW52-10-11183	VOC	SW-846:8260B	Carbon Tetrachloride	1	µg/L	U
10-1683	GW52-10-11183	VOC	SW-846:8260B	Chloro-1,3-butadiene[2-]	1	µg/L	UJ
10-1683	GW52-10-11183	VOC	SW-846:8260B	Chloro-1-propene[3-]	5	µg/L	U
10-1683	GW52-10-11183	VOC	SW-846:8260B	Chlorobenzene	1	µg/L	U
10-1683	GW52-10-11183	VOC	SW-846:8260B	Chlorodibromomethane	1	µg/L	U
10-1683	GW52-10-11183	VOC	SW-846:8260B	Chloroethane	1	µg/L	U
10-1683	GW52-10-11183	VOC	SW-846:8260B	Chloroform	1	µg/L	U
10-1683	GW52-10-11183	VOC	SW-846:8260B	Chloromethane	1	µg/L	U
10-1683	GW52-10-11183	VOC	SW-846:8260B	Chlorotoluene[2-]	1	µg/L	U
10-1683	GW52-10-11183	VOC	SW-846:8260B	Chlorotoluene[4-]	1	µg/L	U
10-1683	GW52-10-11183	VOC	SW-846:8260B	Dibromo-3-Chloropropane[1,2-]	1	µg/L	U
10-1683	GW52-10-11183	VOC	SW-846:8260B	Dibromoethane[1,2-]	1	µg/L	U
10-1683	GW52-10-11183	VOC	SW-846:8260B	Dibromomethane	1	µg/L	U
10-1683	GW52-10-11183	VOC	SW-846:8260B	Dichlorobenzene[1,2-]	1	µg/L	U
10-1683	GW52-10-11183	VOC	SW-846:8260B	Dichlorobenzene[1,3-]	1	µg/L	U
10-1683	GW52-10-11183	VOC	SW-846:8260B	Dichlorobenzene[1,4-]	1	µg/L	U
10-1683	GW52-10-11183	VOC	SW-846:8260B	Dichlorodifluoromethane	1	µg/L	U
10-1683	GW52-10-11183	VOC	SW-846:8260B	Dichloroethane[1,1-]	1	µg/L	U
10-1683	GW52-10-11183	VOC	SW-846:8260B	Dichloroethane[1,2-]	1	µg/L	U
10-1683	GW52-10-11183	VOC	SW-846:8260B	Dichloroethene[1,1-]	1	µg/L	U
10-1683	GW52-10-11183	VOC	SW-846:8260B	Dichloroethene[cis-1,2-]	1	µg/L	U
10-1683	GW52-10-11183	VOC	SW-846:8260B	Dichloroethene[trans-1,2-]	1	µg/L	U
10-1683	GW52-10-11183	VOC	SW-846:8260B	Dichloropropane[1,2-]	1	µg/L	U
10-1683	GW52-10-11183	VOC	SW-846:8260B	Dichloropropane[1,3-]	1	µg/L	U
10-1683	GW52-10-11183	VOC	SW-846:8260B	Dichloropropane[2,2-]	1	µg/L	UJ
10-1683	GW52-10-11183	VOC	SW-846:8260B	Dichloropropene[1,1-]	1	µg/L	U
10-1683	GW52-10-11183	VOC	SW-846:8260B	Dichloropropene[cis-1,3-]	1	µg/L	U
10-1683	GW52-10-11183	VOC	SW-846:8260B	Dichloropropene[trans-1,3-]	1	µg/L	U
10-1683	GW52-10-11183	VOC	SW-846:8260B	Diethyl Ether	1	µg/L	U

Table B-1.3-1 (continued)

Lab Request Number	Sample ID	Analytical Suite Code	Analytical Method Code	Analyte Description	Lab Result	Unit	Validation Qualifier Code
10-1683	GW52-10-11183	VOC	SW-846:8260B	Ethyl Methacrylate	5	µg/L	U
10-1683	GW52-10-11183	VOC	SW-846:8260B	Ethylbenzene	1	µg/L	U
10-1683	GW52-10-11183	VOC	SW-846:8260B	Hexachlorobutadiene	1	µg/L	U
10-1683	GW52-10-11183	VOC	SW-846:8260B	Hexanone[2-]	5	µg/L	U
10-1683	GW52-10-11183	VOC	SW-846:8260B	Iodomethane	5	µg/L	U
10-1683	GW52-10-11183	VOC	SW-846:8260B	Isobutyl alcohol	50	µg/L	R
10-1683	GW52-10-11183	VOC	SW-846:8260B	Isopropylbenzene	1	µg/L	U
10-1683	GW52-10-11183	VOC	SW-846:8260B	Isopropyltoluene[4-]	1	µg/L	U
10-1683	GW52-10-11183	VOC	SW-846:8260B	Methacrylonitrile	5	µg/L	U
10-1683	GW52-10-11183	VOC	SW-846:8260B	Methyl Methacrylate	5	µg/L	U
10-1683	GW52-10-11183	VOC	SW-846:8260B	Methyl tert-Butyl Ether	1	µg/L	U
10-1683	GW52-10-11183	VOC	SW-846:8260B	Methyl-2-pentanone[4-]	5	µg/L	U
10-1683	GW52-10-11183	VOC	SW-846:8260B	Methylene Chloride	10	µg/L	U
10-1683	GW52-10-11183	VOC	SW-846:8260B	Naphthalene	1	µg/L	U
10-1683	GW52-10-11183	VOC	SW-846:8260B	Propionitrile	5	µg/L	R
10-1683	GW52-10-11183	VOC	SW-846:8260B	Propylbenzene[1-]	1	µg/L	U
10-1683	GW52-10-11183	VOC	SW-846:8260B	Styrene	1	µg/L	U
10-1683	GW52-10-11183	VOC	SW-846:8260B	Tetrachloroethane[1,1,1,2-]	1	µg/L	U
10-1683	GW52-10-11183	VOC	SW-846:8260B	Tetrachloroethane[1,1,2,2-]	1	µg/L	U
10-1683	GW52-10-11183	VOC	SW-846:8260B	Tetrachloroethene	1	µg/L	U
10-1683	GW52-10-11183	VOC	SW-846:8260B	Toluene	1	µg/L	U
10-1683	GW52-10-11183	VOC	SW-846:8260B	Trichloro-1,2,2-trifluoroethane[1,1,2-]	5	µg/L	U
10-1683	GW52-10-11183	VOC	SW-846:8260B	Trichlorobenzene[1,2,3-]	1	µg/L	U
10-1683	GW52-10-11183	VOC	SW-846:8260B	Trichlorobenzene[1,2,4-]	1	µg/L	U
10-1683	GW52-10-11183	VOC	SW-846:8260B	Trichloroethane[1,1,1-]	1	µg/L	UJ
10-1683	GW52-10-11183	VOC	SW-846:8260B	Trichloroethane[1,1,2-]	1	µg/L	U
10-1683	GW52-10-11183	VOC	SW-846:8260B	Trichloroethene	1	µg/L	U
10-1683	GW52-10-11183	VOC	SW-846:8260B	Trichlorofluoromethane	1	µg/L	UJ
10-1683	GW52-10-11183	VOC	SW-846:8260B	Trichloropropane[1,2,3-]	1	µg/L	U
10-1683	GW52-10-11183	VOC	SW-846:8260B	Trimethylbenzene[1,2,4-]	1	µg/L	U
10-1683	GW52-10-11183	VOC	SW-846:8260B	Trimethylbenzene[1,3,5-]	1	µg/L	U
10-1683	GW52-10-11183	VOC	SW-846:8260B	Vinyl acetate	5	µg/L	U
10-1683	GW52-10-11183	VOC	SW-846:8260B	Vinyl Chloride	1	µg/L	U
10-1683	GW52-10-11183	VOC	SW-846:8260B	Xylene[1,2-]	1	µg/L	U
10-1683	GW52-10-11183	VOC	SW-846:8260B	Xylene[1,3-]+Xylene[1,4-]	2	µg/L	U
10-1480	GW52-10-11189	HEXP	SW-846:8321A_MOD	2,4-Diamino-6-nitrotoluene	13	µg/L	U

Table B-1.3-1 (continued)

Lab Request Number	Sample ID	Analytical Suite Code	Analytical Method Code	Analyte Description	Lab Result	Unit	Validation Qualifier Code
10-1480	GW52-10-11189	HEXP	SW-846:8321A_MOD	2,6-Diamino-4-nitrotoluene	13	µg/L	U
10-1480	GW52-10-11189	HEXP	SW-846:8321A_MOD	3,5-Dinitroaniline	13	µg/L	U
10-1480	GW52-10-11189	HEXP	SW-846:8321A_MOD	Amino-2,6-dinitrotoluene[4-]	3.25	µg/L	U
10-1480	GW52-10-11189	HEXP	SW-846:8321A_MOD	Amino-4,6-dinitrotoluene[2-]	3.25	µg/L	U
10-1480	GW52-10-11189	HEXP	SW-846:8321A_MOD	Dinitrobenzene[1,3-]	3.25	µg/L	U
10-1480	GW52-10-11189	HEXP	SW-846:8321A_MOD	Dinitrotoluene[2,4-]	3.25	µg/L	U
10-1480	GW52-10-11189	HEXP	SW-846:8321A_MOD	Dinitrotoluene[2,6-]	3.25	µg/L	U
10-1480	GW52-10-11189	HEXP	SW-846:8321A_MOD	HMX	3.25	µg/L	U
10-1480	GW52-10-11189	HEXP	SW-846:8321A_MOD	Nitrobenzene	3.25	µg/L	U
10-1480	GW52-10-11189	HEXP	SW-846:8321A_MOD	Nitrotoluene[2-]	3.25	µg/L	U
10-1480	GW52-10-11189	HEXP	SW-846:8321A_MOD	Nitrotoluene[3-]	3.25	µg/L	U
10-1480	GW52-10-11189	HEXP	SW-846:8321A_MOD	Nitrotoluene[4-]	6.49	µg/L	U
10-1480	GW52-10-11189	HEXP	SW-846:8321A_MOD	PETN	13	µg/L	U
10-1480	GW52-10-11189	HEXP	SW-846:8321A_MOD	RDX	3.25	µg/L	U
10-1480	GW52-10-11189	HEXP	SW-846:8321A_MOD	TATB	13	µg/L	U
10-1480	GW52-10-11189	HEXP	SW-846:8321A_MOD	Tetryl	6.49	µg/L	U
10-1480	GW52-10-11189	HEXP	SW-846:8321A_MOD	Trinitrobenzene[1,3,5-]	3.25	µg/L	U
10-1480	GW52-10-11189	HEXP	SW-846:8321A_MOD	Trinitrotoluene[2,4,6-]	3.25	µg/L	U
10-1480	GW52-10-11189	HEXP	SW-846:8321A_MOD	Tris (o-cresyl) phosphate	13	µg/L	U
10-1611	GW52-10-11189	LH3	Generic:Low_Level_Tritium	Tritium	2.11	TU	NQ[f]
10-1480	GW52-10-11189	METALS	SW-846:6010B	Aluminum	3580	µg/L	NQ
10-1480	GW52-10-11189	METALS	SW-846:6020	Antimony	3	µg/L	U
10-1480	GW52-10-11189	METALS	SW-846:6020	Arsenic	5	µg/L	U
10-1480	GW52-10-11189	METALS	SW-846:6010B	Barium	50	µg/L	U
10-1480	GW52-10-11189	METALS	SW-846:6010B	Beryllium	5	µg/L	U
10-1480	GW52-10-11189	METALS	SW-846:6010B	Boron	132	µg/L	NQ
10-1480	GW52-10-11189	METALS	SW-846:6020	Cadmium	0.413	µg/L	J[g]
10-1480	GW52-10-11189	METALS	SW-846:6010B	Calcium	365000	µg/L	NQ
10-1480	GW52-10-11189	METALS	SW-846:6020	Chromium	10	µg/L	U
10-1480	GW52-10-11189	METALS	SW-846:6010B	Cobalt	210	µg/L	NQ
10-1480	GW52-10-11189	METALS	SW-846:6010B	Copper	100	µg/L	U
10-1480	GW52-10-11189	METALS	SW-846:6010B	Iron	122000	µg/L	NQ
10-1480	GW52-10-11189	METALS	SW-846:6020	Lead	2	µg/L	U
10-1480	GW52-10-11189	METALS	SW-846:6010B	Magnesium	128000	µg/L	NQ
10-1480	GW52-10-11189	METALS	SW-846:6010B	Manganese	8160	µg/L	NQ
10-1480	GW52-10-11189	METALS	EPA:245.2	Mercury	0.2	µg/L	U
10-1480	GW52-10-11189	METALS	SW-846:6020	Molybdenum	2.97	µg/L	NQ
10-1480	GW52-10-11189	METALS	SW-846:6020	Nickel	483	µg/L	NQ

Table B-1.3-1 (continued)

Lab Request Number	Sample ID	Analytical Suite Code	Analytical Method Code	Analyte Description	Lab Result	Unit	Validation Qualifier Code
10-1480	GW52-10-11189	METALS	SW-846:6010B	Potassium	11500	µg/L	NQ
10-1480	GW52-10-11189	METALS	SW-846:6020	Selenium	5	µg/L	U
10-1480	GW52-10-11189	METALS	SW-846:6020	Silver	1	µg/L	U
10-1480	GW52-10-11189	METALS	SW-846:6010B	Sodium	474000	µg/L	NQ
10-1480	GW52-10-11189	METALS	SW-846:6010B	Strontium	340	µg/L	NQ
10-1480	GW52-10-11189	METALS	SW-846:6020	Thallium	1	µg/L	U
10-1480	GW52-10-11189	METALS	SW-846:6010B	Tin	1000	µg/L	U
10-1480	GW52-10-11189	METALS	SW-846:6020	Uranium	1.68	µg/L	NQ
10-1480	GW52-10-11189	METALS	SW-846:6010B	Vanadium	13.3	µg/L	J
10-1480	GW52-10-11189	METALS	SW-846:6010B	Zinc	1400	µg/L	NQ
10-1480	GW52-10-11189	VOC	SW-846:8260B	Acetone	1000	µg/L	U
10-1480	GW52-10-11189	VOC	SW-846:8260B	Acetonitrile	2500	µg/L	U
10-1480	GW52-10-11189	VOC	SW-846:8260B	Acrolein	500	µg/L	U
10-1480	GW52-10-11189	VOC	SW-846:8260B	Acrylonitrile	500	µg/L	U
10-1480	GW52-10-11189	VOC	SW-846:8260B	Benzene	100	µg/L	U
10-1480	GW52-10-11189	VOC	SW-846:8260B	Bromobenzene	100	µg/L	U
10-1480	GW52-10-11189	VOC	SW-846:8260B	Bromochloromethane	100	µg/L	U
10-1480	GW52-10-11189	VOC	SW-846:8260B	Bromodichloromethane	100	µg/L	U
10-1480	GW52-10-11189	VOC	SW-846:8260B	Bromoform	100	µg/L	U
10-1480	GW52-10-11189	VOC	SW-846:8260B	Bromomethane	100	µg/L	U
10-1480	GW52-10-11189	VOC	SW-846:8260B	Butanol[1-]	5000	µg/L	R
10-1480	GW52-10-11189	VOC	SW-846:8260B	Butanone[2-]	500	µg/L	U
10-1480	GW52-10-11189	VOC	SW-846:8260B	Butylbenzene[n-]	100	µg/L	U
10-1480	GW52-10-11189	VOC	SW-846:8260B	Butylbenzene[sec-]	100	µg/L	U
10-1480	GW52-10-11189	VOC	SW-846:8260B	Butylbenzene[tert-]	100	µg/L	U
10-1480	GW52-10-11189	VOC	SW-846:8260B	Carbon Disulfide	500	µg/L	U
10-1480	GW52-10-11189	VOC	SW-846:8260B	Carbon Tetrachloride	100	µg/L	U
10-1480	GW52-10-11189	VOC	SW-846:8260B	Chloro-1,3-butadiene[2-]	100	µg/L	U
10-1480	GW52-10-11189	VOC	SW-846:8260B	Chloro-1-propene[3-]	500	µg/L	U
10-1480	GW52-10-11189	VOC	SW-846:8260B	Chlorobenzene	100	µg/L	U
10-1480	GW52-10-11189	VOC	SW-846:8260B	Chlorodibromomethane	100	µg/L	U
10-1480	GW52-10-11189	VOC	SW-846:8260B	Chloroethane	100	µg/L	U
10-1480	GW52-10-11189	VOC	SW-846:8260B	Chloroform	100	µg/L	U
10-1480	GW52-10-11189	VOC	SW-846:8260B	Chloromethane	100	µg/L	U
10-1480	GW52-10-11189	VOC	SW-846:8260B	Chlorotoluene[2-]	100	µg/L	U
10-1480	GW52-10-11189	VOC	SW-846:8260B	Chlorotoluene[4-]	100	µg/L	U
10-1480	GW52-10-11189	VOC	SW-846:8260B	Dibromo-3-Chloropropane[1,2-]	100	µg/L	U
10-1480	GW52-10-11189	VOC	SW-846:8260B	Dibromoethane[1,2-]	100	µg/L	U

Table B-1.3-1 (continued)

Lab Request Number	Sample ID	Analytical Suite Code	Analytical Method Code	Analyte Description	Lab Result	Unit	Validation Qualifier Code
10-1480	GW52-10-11189	VOC	SW-846:8260B	Dibromomethane	100	µg/L	U
10-1480	GW52-10-11189	VOC	SW-846:8260B	Dichlorobenzene[1,2-]	100	µg/L	U
10-1480	GW52-10-11189	VOC	SW-846:8260B	Dichlorobenzene[1,3-]	100	µg/L	U
10-1480	GW52-10-11189	VOC	SW-846:8260B	Dichlorobenzene[1,4-]	100	µg/L	U
10-1480	GW52-10-11189	VOC	SW-846:8260B	Dichlorodifluoromethane	100	µg/L	U
10-1480	GW52-10-11189	VOC	SW-846:8260B	Dichloroethane[1,1-]	100	µg/L	U
10-1480	GW52-10-11189	VOC	SW-846:8260B	Dichloroethane[1,2-]	100	µg/L	U
10-1480	GW52-10-11189	VOC	SW-846:8260B	Dichloroethene[1,1-]	100	µg/L	U
10-1480	GW52-10-11189	VOC	SW-846:8260B	Dichloroethene[cis-1,2-]	100	µg/L	U
10-1480	GW52-10-11189	VOC	SW-846:8260B	Dichloroethene[trans-1,2-]	100	µg/L	U
10-1480	GW52-10-11189	VOC	SW-846:8260B	Dichloropropane[1,2-]	100	µg/L	U
10-1480	GW52-10-11189	VOC	SW-846:8260B	Dichloropropane[1,3-]	100	µg/L	U
10-1480	GW52-10-11189	VOC	SW-846:8260B	Dichloropropane[2,2-]	100	µg/L	U
10-1480	GW52-10-11189	VOC	SW-846:8260B	Dichloropropene[1,1-]	100	µg/L	U
10-1480	GW52-10-11189	VOC	SW-846:8260B	Dichloropropene[cis-1,3-]	100	µg/L	U
10-1480	GW52-10-11189	VOC	SW-846:8260B	Dichloropropene[trans-1,3-]	100	µg/L	U
10-1480	GW52-10-11189	VOC	SW-846:8260B	Diethyl Ether	100	µg/L	U
10-1480	GW52-10-11189	VOC	SW-846:8260B	Ethyl Methacrylate	500	µg/L	U
10-1480	GW52-10-11189	VOC	SW-846:8260B	Ethylbenzene	100	µg/L	U
10-1480	GW52-10-11189	VOC	SW-846:8260B	Hexachlorobutadiene	100	µg/L	U
10-1480	GW52-10-11189	VOC	SW-846:8260B	Hexanone[2-]	500	µg/L	U
10-1480	GW52-10-11189	VOC	SW-846:8260B	Iodomethane	500	µg/L	U
10-1480	GW52-10-11189	VOC	SW-846:8260B	Isobutyl alcohol	5000	µg/L	R
10-1480	GW52-10-11189	VOC	SW-846:8260B	Isopropylbenzene	100	µg/L	U
10-1480	GW52-10-11189	VOC	SW-846:8260B	Isopropyltoluene[4-]	100	µg/L	U
10-1480	GW52-10-11189	VOC	SW-846:8260B	Methacrylonitrile	500	µg/L	UJ
10-1480	GW52-10-11189	VOC	SW-846:8260B	Methyl Methacrylate	500	µg/L	U
10-1480	GW52-10-11189	VOC	SW-846:8260B	Methyl tert-Butyl Ether	100	µg/L	U
10-1480	GW52-10-11189	VOC	SW-846:8260B	Methyl-2-pentanone[4-]	500	µg/L	U
10-1480	GW52-10-11189	VOC	SW-846:8260B	Methylene Chloride	1000	µg/L	U
10-1480	GW52-10-11189	VOC	SW-846:8260B	Naphthalene	100	µg/L	U
10-1480	GW52-10-11189	VOC	SW-846:8260B	Propionitrile	500	µg/L	R
10-1480	GW52-10-11189	VOC	SW-846:8260B	Propylbenzene[1-]	100	µg/L	U
10-1480	GW52-10-11189	VOC	SW-846:8260B	Styrene	100	µg/L	U
10-1480	GW52-10-11189	VOC	SW-846:8260B	Tetrachloroethane[1,1,1,2-]	100	µg/L	U
10-1480	GW52-10-11189	VOC	SW-846:8260B	Tetrachloroethane[1,1,2,2-]	100	µg/L	U
10-1480	GW52-10-11189	VOC	SW-846:8260B	Tetrachloroethene	100	µg/L	U
10-1480	GW52-10-11189	VOC	SW-846:8260B	Toluene	100	µg/L	U

Table B-1.3-1 (continued)

Lab Request Number	Sample ID	Analytical Suite Code	Analytical Method Code	Analyte Description	Lab Result	Unit	Validation Qualifier Code
10-1480	GW52-10-11189	VOC	SW-846:8260B	Trichloro-1,2,2-trifluoroethane[1,1,2-]	500	µg/L	U
10-1480	GW52-10-11189	VOC	SW-846:8260B	Trichlorobenzene[1,2,3-]	100	µg/L	U
10-1480	GW52-10-11189	VOC	SW-846:8260B	Trichlorobenzene[1,2,4-]	100	µg/L	U
10-1480	GW52-10-11189	VOC	SW-846:8260B	Trichloroethane[1,1,1-]	100	µg/L	U
10-1480	GW52-10-11189	VOC	SW-846:8260B	Trichloroethane[1,1,2-]	100	µg/L	U
10-1480	GW52-10-11189	VOC	SW-846:8260B	Trichloroethene	100	µg/L	U
10-1480	GW52-10-11189	VOC	SW-846:8260B	Trichlorofluoromethane	100	µg/L	U
10-1480	GW52-10-11189	VOC	SW-846:8260B	Trichloropropane[1,2,3-]	100	µg/L	U
10-1480	GW52-10-11189	VOC	SW-846:8260B	Trimethylbenzene[1,2,4-]	100	µg/L	U
10-1480	GW52-10-11189	VOC	SW-846:8260B	Trimethylbenzene[1,3,5-]	100	µg/L	U
10-1480	GW52-10-11189	VOC	SW-846:8260B	Vinyl acetate	500	µg/L	U
10-1480	GW52-10-11189	VOC	SW-846:8260B	Vinyl Chloride	100	µg/L	U
10-1480	GW52-10-11189	VOC	SW-846:8260B	Xylene[1,2-]	100	µg/L	U
10-1480	GW52-10-11189	VOC	SW-846:8260B	Xylene[1,3-]+Xylene[1,4-]	200	µg/L	U
10-1480	GW52-10-11189	WET_CHEM	SM:A2340B	Hardness	1440	mg/L	NQ
10-1683	GW52-10-11849	HEXP	SW-846:8321A_MOD	2,4-Diamino-6-nitrotoluene	13	µg/L	U
10-1683	GW52-10-11849	HEXP	SW-846:8321A_MOD	2,6-Diamino-4-nitrotoluene	13	µg/L	U
10-1683	GW52-10-11849	HEXP	SW-846:8321A_MOD	3,5-Dinitroaniline	13	µg/L	U
10-1683	GW52-10-11849	HEXP	SW-846:8321A_MOD	Amino-2,6-dinitrotoluene[4-]	3.25	µg/L	U
10-1683	GW52-10-11849	HEXP	SW-846:8321A_MOD	Amino-4,6-dinitrotoluene[2-]	3.25	µg/L	U
10-1683	GW52-10-11849	HEXP	SW-846:8321A_MOD	Dinitrobenzene[1,3-]	3.25	µg/L	U
10-1683	GW52-10-11849	HEXP	SW-846:8321A_MOD	Dinitrotoluene[2,4-]	3.25	µg/L	U
10-1683	GW52-10-11849	HEXP	SW-846:8321A_MOD	Dinitrotoluene[2,6-]	3.25	µg/L	U
10-1683	GW52-10-11849	HEXP	SW-846:8321A_MOD	HMX	3.25	µg/L	U
10-1683	GW52-10-11849	HEXP	SW-846:8321A_MOD	Nitrobenzene	3.25	µg/L	U
10-1683	GW52-10-11849	HEXP	SW-846:8321A_MOD	Nitrotoluene[2-]	3.25	µg/L	U
10-1683	GW52-10-11849	HEXP	SW-846:8321A_MOD	Nitrotoluene[3-]	3.25	µg/L	U
10-1683	GW52-10-11849	HEXP	SW-846:8321A_MOD	Nitrotoluene[4-]	6.49	µg/L	U
10-1683	GW52-10-11849	HEXP	SW-846:8321A_MOD	PETN	13	µg/L	U
10-1683	GW52-10-11849	HEXP	SW-846:8321A_MOD	RDX	3.25	µg/L	U
10-1683	GW52-10-11849	HEXP	SW-846:8321A_MOD	TATB	13	µg/L	U
10-1683	GW52-10-11849	HEXP	SW-846:8321A_MOD	Tetryl	6.49	µg/L	U
10-1683	GW52-10-11849	HEXP	SW-846:8321A_MOD	Trinitrobenzene[1,3,5-]	3.25	µg/L	U
10-1683	GW52-10-11849	HEXP	SW-846:8321A_MOD	Trinitrotoluene[2,4,6-]	3.25	µg/L	U
10-1683	GW52-10-11849	HEXP	SW-846:8321A_MOD	Tris (o-cresyl) phosphate	13	µg/L	U
10-1684	GW52-10-11849	LH3	Generic:Low_Level_Tritium	Tritium	0.09	TU	U
10-1683	GW52-10-11849	VOC	SW-846:8260B	Acetone	10	µg/L	UJ
10-1683	GW52-10-11849	VOC	SW-846:8260B	Acetonitrile	25	µg/L	R

Table B-1.3-1 (continued)

Lab Request Number	Sample ID	Analytical Suite Code	Analytical Method Code	Analyte Description	Lab Result	Unit	Validation Qualifier Code
10-1683	GW52-10-11849	VOC	SW-846:8260B	Acrolein	5	µg/L	R
10-1683	GW52-10-11849	VOC	SW-846:8260B	Acrylonitrile	5	µg/L	UJ
10-1683	GW52-10-11849	VOC	SW-846:8260B	Benzene	1	µg/L	UJ
10-1683	GW52-10-11849	VOC	SW-846:8260B	Bromobenzene	1	µg/L	UJ
10-1683	GW52-10-11849	VOC	SW-846:8260B	Bromochloromethane	1	µg/L	UJ
10-1683	GW52-10-11849	VOC	SW-846:8260B	Bromodichloromethane	1	µg/L	UJ
10-1683	GW52-10-11849	VOC	SW-846:8260B	Bromoform	1	µg/L	UJ
10-1683	GW52-10-11849	VOC	SW-846:8260B	Bromomethane	1	µg/L	UJ
10-1683	GW52-10-11849	VOC	SW-846:8260B	Butanol[1-]	50	µg/L	UJ
10-1683	GW52-10-11849	VOC	SW-846:8260B	Butanone[2-]	5	µg/L	UJ
10-1683	GW52-10-11849	VOC	SW-846:8260B	Butylbenzene[n-]	1	µg/L	UJ
10-1683	GW52-10-11849	VOC	SW-846:8260B	Butylbenzene[sec-]	1	µg/L	UJ
10-1683	GW52-10-11849	VOC	SW-846:8260B	Butylbenzene[tert-]	1	µg/L	UJ
10-1683	GW52-10-11849	VOC	SW-846:8260B	Carbon Disulfide	5	µg/L	UJ
10-1683	GW52-10-11849	VOC	SW-846:8260B	Carbon Tetrachloride	1	µg/L	UJ
10-1683	GW52-10-11849	VOC	SW-846:8260B	Chloro-1,3-butadiene[2-]	1	µg/L	UJ
10-1683	GW52-10-11849	VOC	SW-846:8260B	Chloro-1-propene[3-]	5	µg/L	UJ
10-1683	GW52-10-11849	VOC	SW-846:8260B	Chlorobenzene	1	µg/L	UJ
10-1683	GW52-10-11849	VOC	SW-846:8260B	Chlorodibromomethane	1	µg/L	UJ
10-1683	GW52-10-11849	VOC	SW-846:8260B	Chloroethane	1	µg/L	UJ
10-1683	GW52-10-11849	VOC	SW-846:8260B	Chloroform	1	µg/L	UJ
10-1683	GW52-10-11849	VOC	SW-846:8260B	Chloromethane	1	µg/L	UJ
10-1683	GW52-10-11849	VOC	SW-846:8260B	Chlorotoluene[2-]	1	µg/L	UJ
10-1683	GW52-10-11849	VOC	SW-846:8260B	Chlorotoluene[4-]	1	µg/L	UJ
10-1683	GW52-10-11849	VOC	SW-846:8260B	Dibromo-3-Chloropropane[1,2-]	1	µg/L	UJ
10-1683	GW52-10-11849	VOC	SW-846:8260B	Dibromoethane[1,2-]	1	µg/L	UJ
10-1683	GW52-10-11849	VOC	SW-846:8260B	Dibromomethane	1	µg/L	UJ
10-1683	GW52-10-11849	VOC	SW-846:8260B	Dichlorobenzene[1,2-]	1	µg/L	UJ
10-1683	GW52-10-11849	VOC	SW-846:8260B	Dichlorobenzene[1,3-]	1	µg/L	UJ
10-1683	GW52-10-11849	VOC	SW-846:8260B	Dichlorobenzene[1,4-]	1	µg/L	UJ
10-1683	GW52-10-11849	VOC	SW-846:8260B	Dichlorodifluoromethane	1	µg/L	UJ
10-1683	GW52-10-11849	VOC	SW-846:8260B	Dichloroethane[1,1-]	1	µg/L	UJ
10-1683	GW52-10-11849	VOC	SW-846:8260B	Dichloroethane[1,2-]	1	µg/L	UJ
10-1683	GW52-10-11849	VOC	SW-846:8260B	Dichloroethene[1,1-]	1	µg/L	UJ
10-1683	GW52-10-11849	VOC	SW-846:8260B	Dichloroethene[cis-1,2-]	1	µg/L	UJ
10-1683	GW52-10-11849	VOC	SW-846:8260B	Dichloroethene[trans-1,2-]	1	µg/L	UJ
10-1683	GW52-10-11849	VOC	SW-846:8260B	Dichloropropane[1,2-]	1	µg/L	UJ
10-1683	GW52-10-11849	VOC	SW-846:8260B	Dichloropropane[1,3-]	1	µg/L	UJ

Table B-1.3-1 (continued)

Lab Request Number	Sample ID	Analytical Suite Code	Analytical Method Code	Analyte Description	Lab Result	Unit	Validation Qualifier Code
10-1683	GW52-10-11849	VOC	SW-846:8260B	Dichloropropane[2,2-]	1	µg/L	UJ
10-1683	GW52-10-11849	VOC	SW-846:8260B	Dichloropropene[1,1-]	1	µg/L	UJ
10-1683	GW52-10-11849	VOC	SW-846:8260B	Dichloropropene[cis-1,3-]	1	µg/L	UJ
10-1683	GW52-10-11849	VOC	SW-846:8260B	Dichloropropene[trans-1,3-]	1	µg/L	UJ
10-1683	GW52-10-11849	VOC	SW-846:8260B	Diethyl Ether	1	µg/L	UJ
10-1683	GW52-10-11849	VOC	SW-846:8260B	Ethyl Methacrylate	5	µg/L	UJ
10-1683	GW52-10-11849	VOC	SW-846:8260B	Ethylbenzene	1	µg/L	UJ
10-1683	GW52-10-11849	VOC	SW-846:8260B	Hexachlorobutadiene	1	µg/L	UJ
10-1683	GW52-10-11849	VOC	SW-846:8260B	Hexanone[2-]	5	µg/L	UJ
10-1683	GW52-10-11849	VOC	SW-846:8260B	Iodomethane	5	µg/L	UJ
10-1683	GW52-10-11849	VOC	SW-846:8260B	Isobutyl alcohol	50	µg/L	R
10-1683	GW52-10-11849	VOC	SW-846:8260B	Isopropylbenzene	1	µg/L	UJ
10-1683	GW52-10-11849	VOC	SW-846:8260B	Isopropyltoluene[4-]	1	µg/L	UJ
10-1683	GW52-10-11849	VOC	SW-846:8260B	Methacrylonitrile	5	µg/L	UJ
10-1683	GW52-10-11849	VOC	SW-846:8260B	Methyl Methacrylate	5	µg/L	UJ
10-1683	GW52-10-11849	VOC	SW-846:8260B	Methyl tert-Butyl Ether	1	µg/L	UJ
10-1683	GW52-10-11849	VOC	SW-846:8260B	Methyl-2-pentanone[4-]	5	µg/L	UJ
10-1683	GW52-10-11849	VOC	SW-846:8260B	Methylene Chloride	10	µg/L	UJ
10-1683	GW52-10-11849	VOC	SW-846:8260B	Naphthalene	1	µg/L	UJ
10-1683	GW52-10-11849	VOC	SW-846:8260B	Propionitrile	5	µg/L	R
10-1683	GW52-10-11849	VOC	SW-846:8260B	Propylbenzene[1-]	1	µg/L	UJ
10-1683	GW52-10-11849	VOC	SW-846:8260B	Styrene	1	µg/L	UJ
10-1683	GW52-10-11849	VOC	SW-846:8260B	Tetrachloroethane[1,1,1,2-]	1	µg/L	UJ
10-1683	GW52-10-11849	VOC	SW-846:8260B	Tetrachloroethane[1,1,2,2-]	1	µg/L	UJ
10-1683	GW52-10-11849	VOC	SW-846:8260B	Tetrachloroethene	1	µg/L	UJ
10-1683	GW52-10-11849	VOC	SW-846:8260B	Toluene	1	µg/L	UJ
10-1683	GW52-10-11849	VOC	SW-846:8260B	Trichloro-1,2,2-trifluoroethane[1,1,2-]	5	µg/L	UJ
10-1683	GW52-10-11849	VOC	SW-846:8260B	Trichlorobenzene[1,2,3-]	1	µg/L	UJ
10-1683	GW52-10-11849	VOC	SW-846:8260B	Trichlorobenzene[1,2,4-]	1	µg/L	UJ
10-1683	GW52-10-11849	VOC	SW-846:8260B	Trichloroethane[1,1,1-]	1	µg/L	UJ
10-1683	GW52-10-11849	VOC	SW-846:8260B	Trichloroethane[1,1,2-]	1	µg/L	UJ
10-1683	GW52-10-11849	VOC	SW-846:8260B	Trichloroethene	1	µg/L	UJ
10-1683	GW52-10-11849	VOC	SW-846:8260B	Trichlorofluoromethane	1	µg/L	UJ
10-1683	GW52-10-11849	VOC	SW-846:8260B	Trichloropropane[1,2,3-]	1	µg/L	UJ
10-1683	GW52-10-11849	VOC	SW-846:8260B	Trimethylbenzene[1,2,4-]	1	µg/L	UJ
10-1683	GW52-10-11849	VOC	SW-846:8260B	Trimethylbenzene[1,3,5-]	1	µg/L	UJ
10-1683	GW52-10-11849	VOC	SW-846:8260B	Vinyl acetate	5	µg/L	UJ
10-1683	GW52-10-11849	VOC	SW-846:8260B	Vinyl Chloride	1	µg/L	UJ

Table B-1.3-1 (continued)

Lab Request Number	Sample ID	Analytical Suite Code	Analytical Method Code	Analyte Description	Lab Result	Unit	Validation Qualifier Code
10-1683	GW52-10-11849	VOC	SW-846:8260B	Xylene[1,2-]	1	µg/L	UJ
10-1683	GW52-10-11849	VOC	SW-846:8260B	Xylene[1,3-]+Xylene[1,4-]	2	µg/L	UJ
10-1683	GW52-10-11850	VOC	SW-846:8260B	Acetone	10	µg/L	U
10-1683	GW52-10-11850	VOC	SW-846:8260B	Acetonitrile	25	µg/L	R
10-1683	GW52-10-11850	VOC	SW-846:8260B	Acrolein	5	µg/L	U
10-1683	GW52-10-11850	VOC	SW-846:8260B	Acrylonitrile	5	µg/L	U
10-1683	GW52-10-11850	VOC	SW-846:8260B	Benzene	1	µg/L	U
10-1683	GW52-10-11850	VOC	SW-846:8260B	Bromobenzene	1	µg/L	U
10-1683	GW52-10-11850	VOC	SW-846:8260B	Bromochloromethane	1	µg/L	U
10-1683	GW52-10-11850	VOC	SW-846:8260B	Bromodichloromethane	1	µg/L	U
10-1683	GW52-10-11850	VOC	SW-846:8260B	Bromoform	1	µg/L	U
10-1683	GW52-10-11850	VOC	SW-846:8260B	Bromomethane	1	µg/L	U
10-1683	GW52-10-11850	VOC	SW-846:8260B	Butanol[1-]	50	µg/L	R
10-1683	GW52-10-11850	VOC	SW-846:8260B	Butanone[2-]	5	µg/L	U
10-1683	GW52-10-11850	VOC	SW-846:8260B	Butylbenzene[n-]	1	µg/L	U
10-1683	GW52-10-11850	VOC	SW-846:8260B	Butylbenzene[sec-]	1	µg/L	U
10-1683	GW52-10-11850	VOC	SW-846:8260B	Butylbenzene[tert-]	1	µg/L	U
10-1683	GW52-10-11850	VOC	SW-846:8260B	Carbon Disulfide	5	µg/L	U
10-1683	GW52-10-11850	VOC	SW-846:8260B	Carbon Tetrachloride	1	µg/L	U
10-1683	GW52-10-11850	VOC	SW-846:8260B	Chloro-1,3-butadiene[2-]	1	µg/L	UJ
10-1683	GW52-10-11850	VOC	SW-846:8260B	Chloro-1-propene[3-]	5	µg/L	U
10-1683	GW52-10-11850	VOC	SW-846:8260B	Chlorobenzene	1	µg/L	U
10-1683	GW52-10-11850	VOC	SW-846:8260B	Chlorodibromomethane	1	µg/L	U
10-1683	GW52-10-11850	VOC	SW-846:8260B	Chloroethane	1	µg/L	U
10-1683	GW52-10-11850	VOC	SW-846:8260B	Chloroform	1	µg/L	U
10-1683	GW52-10-11850	VOC	SW-846:8260B	Chloromethane	1	µg/L	U
10-1683	GW52-10-11850	VOC	SW-846:8260B	Chlorotoluene[2-]	1	µg/L	U
10-1683	GW52-10-11850	VOC	SW-846:8260B	Chlorotoluene[4-]	1	µg/L	U
10-1683	GW52-10-11850	VOC	SW-846:8260B	Dibromo-3-Chloropropane[1,2-]	1	µg/L	U
10-1683	GW52-10-11850	VOC	SW-846:8260B	Dibromoethane[1,2-]	1	µg/L	U
10-1683	GW52-10-11850	VOC	SW-846:8260B	Dibromomethane	1	µg/L	U
10-1683	GW52-10-11850	VOC	SW-846:8260B	Dichlorobenzene[1,2-]	1	µg/L	U
10-1683	GW52-10-11850	VOC	SW-846:8260B	Dichlorobenzene[1,3-]	1	µg/L	U
10-1683	GW52-10-11850	VOC	SW-846:8260B	Dichlorobenzene[1,4-]	1	µg/L	U
10-1683	GW52-10-11850	VOC	SW-846:8260B	Dichlorodifluoromethane	1	µg/L	U
10-1683	GW52-10-11850	VOC	SW-846:8260B	Dichloroethane[1,1-]	1	µg/L	U
10-1683	GW52-10-11850	VOC	SW-846:8260B	Dichloroethane[1,2-]	1	µg/L	U
10-1683	GW52-10-11850	VOC	SW-846:8260B	Dichloroethene[1,1-]	1	µg/L	U

Table B-1.3-1 (continued)

Lab Request Number	Sample ID	Analytical Suite Code	Analytical Method Code	Analyte Description	Lab Result	Unit	Validation Qualifier Code
10-1683	GW52-10-11850	VOC	SW-846:8260B	Dichloroethene[cis-1,2-]	1	µg/L	U
10-1683	GW52-10-11850	VOC	SW-846:8260B	Dichloroethene[trans-1,2-]	1	µg/L	U
10-1683	GW52-10-11850	VOC	SW-846:8260B	Dichloropropane[1,2-]	1	µg/L	U
10-1683	GW52-10-11850	VOC	SW-846:8260B	Dichloropropane[1,3-]	1	µg/L	U
10-1683	GW52-10-11850	VOC	SW-846:8260B	Dichloropropane[2,2-]	1	µg/L	UJ
10-1683	GW52-10-11850	VOC	SW-846:8260B	Dichloropropene[1,1-]	1	µg/L	U
10-1683	GW52-10-11850	VOC	SW-846:8260B	Dichloropropene[cis-1,3-]	1	µg/L	U
10-1683	GW52-10-11850	VOC	SW-846:8260B	Dichloropropene[trans-1,3-]	1	µg/L	U
10-1683	GW52-10-11850	VOC	SW-846:8260B	Diethyl Ether	1	µg/L	U
10-1683	GW52-10-11850	VOC	SW-846:8260B	Ethyl Methacrylate	5	µg/L	U
10-1683	GW52-10-11850	VOC	SW-846:8260B	Ethylbenzene	1	µg/L	U
10-1683	GW52-10-11850	VOC	SW-846:8260B	Hexachlorobutadiene	1	µg/L	U
10-1683	GW52-10-11850	VOC	SW-846:8260B	Hexanone[2-]	5	µg/L	U
10-1683	GW52-10-11850	VOC	SW-846:8260B	Iodomethane	5	µg/L	U
10-1683	GW52-10-11850	VOC	SW-846:8260B	Isobutyl alcohol	50	µg/L	R
10-1683	GW52-10-11850	VOC	SW-846:8260B	Isopropylbenzene	1	µg/L	U
10-1683	GW52-10-11850	VOC	SW-846:8260B	Isopropyltoluene[4-]	1	µg/L	U
10-1683	GW52-10-11850	VOC	SW-846:8260B	Methacrylonitrile	5	µg/L	U
10-1683	GW52-10-11850	VOC	SW-846:8260B	Methyl Methacrylate	5	µg/L	U
10-1683	GW52-10-11850	VOC	SW-846:8260B	Methyl tert-Butyl Ether	1	µg/L	U
10-1683	GW52-10-11850	VOC	SW-846:8260B	Methyl-2-pentanone[4-]	5	µg/L	U
10-1683	GW52-10-11850	VOC	SW-846:8260B	Methylene Chloride	10	µg/L	U
10-1683	GW52-10-11850	VOC	SW-846:8260B	Naphthalene	1	µg/L	U
10-1683	GW52-10-11850	VOC	SW-846:8260B	Propionitrile	5	µg/L	R
10-1683	GW52-10-11850	VOC	SW-846:8260B	Propylbenzene[1-]	1	µg/L	U
10-1683	GW52-10-11850	VOC	SW-846:8260B	Styrene	1	µg/L	U
10-1683	GW52-10-11850	VOC	SW-846:8260B	Tetrachloroethane[1,1,1,2-]	1	µg/L	U
10-1683	GW52-10-11850	VOC	SW-846:8260B	Tetrachloroethane[1,1,2,2-]	1	µg/L	U
10-1683	GW52-10-11850	VOC	SW-846:8260B	Tetrachloroethene	1	µg/L	U
10-1683	GW52-10-11850	VOC	SW-846:8260B	Toluene	1	µg/L	U
10-1683	GW52-10-11850	VOC	SW-846:8260B	Trichloro-1,2,2-trifluoroethane[1,1,2-]	5	µg/L	U
10-1683	GW52-10-11850	VOC	SW-846:8260B	Trichlorobenzene[1,2,3-]	1	µg/L	U
10-1683	GW52-10-11850	VOC	SW-846:8260B	Trichlorobenzene[1,2,4-]	1	µg/L	U
10-1683	GW52-10-11850	VOC	SW-846:8260B	Trichloroethane[1,1,1-]	1	µg/L	UJ
10-1683	GW52-10-11850	VOC	SW-846:8260B	Trichloroethane[1,1,2-]	1	µg/L	U
10-1683	GW52-10-11850	VOC	SW-846:8260B	Trichloroethene	1	µg/L	U
10-1683	GW52-10-11850	VOC	SW-846:8260B	Trichlorofluoromethane	1	µg/L	UJ
10-1683	GW52-10-11850	VOC	SW-846:8260B	Trichloropropane[1,2,3-]	1	µg/L	U

Table B-1.3-1 (continued)

Lab Request Number	Sample ID	Analytical Suite Code	Analytical Method Code	Analyte Description	Lab Result	Unit	Validation Qualifier Code
10-1683	GW52-10-11850	VOC	SW-846:8260B	Trimethylbenzene[1,2,4-]	1	µg/L	U
10-1683	GW52-10-11850	VOC	SW-846:8260B	Trimethylbenzene[1,3,5-]	1	µg/L	U
10-1683	GW52-10-11850	VOC	SW-846:8260B	Vinyl acetate	5	µg/L	U
10-1683	GW52-10-11850	VOC	SW-846:8260B	Vinyl Chloride	1	µg/L	U
10-1683	GW52-10-11850	VOC	SW-846:8260B	Xylene[1,2-]	1	µg/L	U
10-1683	GW52-10-11850	VOC	SW-846:8260B	Xylene[1,3-]+Xylene[1,4-]	2	µg/L	U

Note: Samples GW52-10-11183 and GW52-10-11850 are trip blanks for samples GW52-10-11182 and GW52-10-11849, respectively.

[a] U = The analyte was analyzed for but not detected.

[b] TU = Tritium unit.

[c] J- = The analyte was positively identified, and the result is likely to be biased low.

[d] R = The data are rejected as a result of major problems with quality assurance/quality control parameters.

[e] UJ = The analyte was not positively identified in the sample, and the associated value is an estimate of the sample-specific detection or quantitation limit.

[f] NQ = Data are valid and not qualified.

[g] J = The analyte was positively identified, and the associated numerical value is estimated to be more uncertain than would normally be expected for that analysis.

Table B-1.3-2
EES-14 Analytical Results

Sample ID	Date Received	Sample Type	ER/RRES-WQH	Depth (feet)	Ag rslt (ppm)	stdev (Ag)	Al rslt (ppm)	stdev (Al)	As rslt (ppm)	stdev (As)	B rslt (ppm)
GW52-10-11189	1/28/2010	Borehole	10-1479	916	0.001	U*	3.53	0.01	0.0010	0.0000	0.223
GW52-10-11182	2/8/2010	Borehole	10-1682	1054	0.001	U	0.04	0.00	0.0007	0.0001	0.278
GW52-10-11849	2/8/2010	Borehole	10-1682	1174.5	0.001	U	0.25	0.00	0.0010	0.0000	0.173
GW52-10-15465	4/20/2010	Development, Lower screen	10-2829	1107.0–1117.0	0.001	U	0.004	0.000	0.0010	0.0000	0.118
GW52-10-11188	5/5/2010	Development, Upper screen	10-2972	1035.2–1056.7	0.001	U	0.002	U	0.0007	0.0000	0.047

stdev (B)	Ba rslt (ppm)	stdev (Ba)	Be rslt (ppm)	stdev (Be)	Br(-) ppm	Ca rslt (ppm)	stdev (Ca)	Cd rslt (ppm)	stdev (Cd)	Cl(-) ppm	ClO4(-) ppm
0.001	0.509	0.003	0.001	U	0.19	47.49	0.64	0.001	U	79.9	0.005
0.001	1.047	0.005	0.001	U	0.07	10.71	0.09	0.001	U	7.60	0.005
0.001	0.783	0.002	0.001	U	0.03	16.82	0.11	0.001	U	10.5	0.005
0.002	0.433	0.004	0.001	U	0.01, U	11.28	0.03	0.001	U	4.2	0.005
0.001	0.262	0.000	0.001	U	0.01, U	10.62	0.04	0.001	U	3.93	0.005

ClO4(-) (U)	Co rslt (ppm)	stdev (Co)	Alk-CO3 rslt (ppm)	Cr rslt (ppm)	stdev (Cr)	Cs rslt (ppm)	stdev (Cs)	Cu rslt (ppm)	stdev (Cu)	F(-) ppm	Fe rslt (ppm)
U	0.003	0.000	36.9	0.004	0.000	0.001	U	0.149	0.001	1.02	2.26
U	0.001	U	0.8, U	0.002	0.000	0.001	U	0.001	U	0.50	0.12
U	0.001	U	0.8, U	0.002	0.000	0.001	U	0.001	0.000	0.38	0.13
U	0.001	U	0.8, U	0.002	0.000	0.001	U	0.001	U	0.30	0.19
U	0.001	U	0.8, U	0.002	0.000	0.001	U	0.001	U	0.20	0.29

stdev (Fe)	Alk-CO3+HCO3 rslt (ppm)	Hg rslt (ppm)	stdev (Hg)	K rslt (ppm)	stdev (K)	Li rslt (ppm)	stdev (Li)	Mg rslt (ppm)	stdev (Mg)	Mn rslt (ppm)	stdev (Mn)
0.01	451	0.00366	0.00055	3.77	0.03	0.009	0.000	9.69	0.06	0.056	0.000
0.00	92	0.00046	0.00017	1.57	0.02	0.034	0.000	2.81	0.02	0.259	0.001
0.00	128	0.00037	0.00001	3.47	0.01	0.035	0.000	5.37	0.00	0.074	0.001
0.00	82	0.00005	U	1.62	0.01	0.022	0.000	2.84	0.03	0.023	0.000
0.00	84	0.00007	0.00001	1.61	0.01	0.028	0.002	2.85	0.03	0.044	0.001

Mo rslt (ppm)	stdev (Mo)	Na rslt (ppm)	stdev (Na)	Ni rslt (ppm)	stdev (Ni)	NO2(ppm)	NO2-N rslt	NO3 ppm	NO3-N rslt	C2O4 rslt (ppm)	Pb rslt (ppm)
0.157	0.000	237	2	0.018	0.001	0.01	0.003, U	0.38	0.09	1.4	0.0004
0.014	0.000	18.0	0.1	0.003	0.000	0.01	0.003, U	2.60	0.59	0.28	0.0002
0.005	0.000	20.74	0.17	0.004	0.000	0.01	0.003. U	1.88	0.42	0.01, U	0.0002
0.002	0.000	17.03	0.20	0.002	0.000	0.01	0.003, U	2.46	0.55	0.01, U	0.0002
0.002	0.000	15.54	0.07	0.001	0.000	0.01	0.003, U	1.47	0.33	0.01, U	0.0002

Table B-1.3-2 (continued)

stdev (Pb)	Lab pH	PO4(-3) rslt (ppm)	Rb rslt (ppm)	stdev (Rb)	Sb rslt (ppm)	stdev (Sb)	Se rslt (ppm)	stdev (Se)	Si rslt (ppm)	stdev (Si)	SiO2 rslt (ppm)
0.0000	9.16	0.01, U	0.005	0.000	0.001	U	0.010	0.000	14.2	0.1	30.4
U	7.31	0.01, U	0.001	U	0.001	U	0.001	U	13.4	0.1	28.8
U	7.60	0.14	0.003	0.000	0.001	U	0.001	U	31.1	0.1	66.5
0.0000	7.68	0.06	0.001	0.000	0.001	U	0.001	U	34.5	0.2	73.9
U	7.63	0.01, U	0.002	0.000	0.001	U	0.001	U	33.6	0.1	71.8

stdev (SiO2)	Sn rslt (ppm)	stdev (Sn)	SO4(-2) rslt (ppm)	Sr rslt (ppm)	stdev (Sr)	Th rslt (ppm)	stdev (Th)	Ti rslt (ppm)	stdev (Ti)	Tl rslt (ppm)	stdev (Tl)
0.2	0.001	U	27.7	0.107	0.001	0.001	U	0.059	0.001	0.001	U
0.1	0.001	U	4.08	0.044	0.000	0.001	U	0.008	0.000	0.001	U
0.3	0.001	U	4.40	0.071	0.001	0.001	U	0.006	0.000	0.001	U
0.4	0.001	U	7.85	0.049	0.000	0.001	U	0.002		0.001	U
0.2	0.001	U	6.06	0.049	0.001	0.001	U	0.002	U	0.001	U

U rslt (ppm)	stdev (U)	V rslt (ppm)	stdev (V)	Zn rslt (ppm)	stdev (Zn)	TDS (ppm)	Cations	Anions	Balance
0.0009	0.0000	0.011	0.000	0.036	0.000	933	13.59	11.58	0.08
0.0002	U	0.001	U	0.037	0.000	171	1.62	1.90	-0.08
0.0024	0.0000	0.003	0.000	0.072	0.001	259	2.29	2.54	-0.05
0.0004	0.0000	0.005	0.000	0.056	0.008	204	1.59	1.69	-0.03
0.0003	0.0000	0.005	0.000	0.066	0.001	199	1.49	1.65	-0.05

*U = Not detected.

Table B-1.3-3
TOC Analytical Results

Sample ID	TOC (ppm)
GW52-10-15463	0.30
GW52-10-15464	0.20, U*
GW52-10-15465	0.20, U
GW52-10-11184	0.52
GW52-10-11185	0.27
GW52-10-11188	0.26

*U = Not detected.

Appendix C

Borehole Video Logging
(on DVD included with this document)

Appendix D

Geophysical Logs
(on CD included with this document)

Appendix E

Aquifer Testing Report

E-1.0 INTRODUCTION

This appendix describes the hydraulic analysis of pumping tests conducted during April and May 2010 at R-52, a dual-screen regional aquifer well located on a narrow mesa between the north and south forks of Cañada del Buey and about 860 ft west-northwest of well R-37. The tests on R-52 were conducted to quantify the hydraulic properties of the two zones in which the well is screened, evaluate the hydraulic interconnection of the zones, and check for interference effects at nearby regional well R-37.

Testing planned for each screen interval consisted of brief trial pumping, background water-level data collection, and a 24-h constant-rate pumping test. Water levels were monitored in both zones during each of the pumping tests in each screen.

As in most of the R-well pumping tests conducted on the Pajarito Plateau (the Plateau), an inflatable packer system was used in R-52 to both hydraulically isolate the screen zones and to try to eliminate casing-storage effects on the test data. Storage effects appeared to have been eliminated successfully from most of the tests. In a couple of cases, however, it appeared that minor gas buildup beneath the upper packer may have caused a storage-like response in the recovery data from screen 2.

A side effect of using the inflatable packer assembly was leakage of water from the drop pipe into the well caused by failure of an O-ring seal where the submersible pump wires pass through the drop pipe above the packer. This had the effect of allowing water to leak from the drop pipe into the screen 1 zone during pumping of screen 2, obscuring the screen 1 response to pumping screen 2. Because of this failure, the contractor was asked to replace the O-ring seals in the packer assembly and run a repeat test on screen 2. Unfortunately, the seals failed again during the supplemental test.

Air or gas was produced with the groundwater from both screen zones, similar to what has been observed in many of the recent pumping tests on the Plateau. The greatest gas contribution appeared to come from screen 2. It is not known whether the source of the gas is natural or a byproduct of air-drilling the boreholes.

Conceptual Hydrogeology

Both screens in R-52 lie within sands and gravels of the Puye Formation. Screen 1 is 20.5 ft long, extending from 1035.2 to 1055.7 ft below ground surface (bgs). Screen 2 is 10 ft long and is positioned more than 50 ft beneath screen 1, extending from 1107 to 1127 ft bgs.

The composite static water level measured on April 20, 2010, before testing was 1017.96 ft bgs. The ground surface elevation (brass cap) at the well was surveyed at 6883.04 ft above mean sea level (amsl), making the composite water-level elevation 5865.08 ft amsl.

When the screen zones were isolated using an inflatable packer, the water level in screen 1 rose 0.60 ft to a depth of 1017.36 ft bgs and an elevation of 5865.68 ft amsl. At the same time, the water level in screen 2 declined 1.18 ft, making its depth to water 1019.14 ft bgs at an elevation of 5863.90 ft amsl. Thus, the water levels showed a head difference of 1.78 ft and a downward hydraulic gradient, implying the existence of resistive sediments between the two screen zones.

No specific aquitards were identified in the saturated interval penetrated by R-52. Thus, the effective aquifer thickness of the hydraulically contiguous zone associated with each screen interval was not known.

Aerated Groundwater

Consistent with observations in many of the recent R-well pumping tests, presence of air or gas was detected in the groundwater during the R-52 pumping tests. It is possible that the observed gas is natural. However, it is also possible that high-pressure compressed air used in the drilling process invaded the aquifer zones during drilling, collecting in the formation pore spaces and/or dissolving in the groundwater. When water is pumped from the aquifer, trapped gas or air in the formation pores can move with the pumped water as well as expand and contract in response to pressure changes. Also, pressure reduction or turbid flow associated with pumping can allow dissolved gas or air to come out of solution. The significant quantity of gas or air present in the formations in recently tested wells has had several effects including (1) interfering with pump operating efficiency, (2) causing transient changes in aquifer permeability, (3) inducing abnormal pressure transients as the gas or air expands and contracts, and (4) causing storage-like effects associated with changes in gas or air volume in the formation voids, filter pack, and/or well casing.

The presence of air or gas in the R-52 tests appeared to contribute to accumulation of air in the well during the 24-h tests on the two screens. The effect in screen 2 was minor, causing a storage-like effect in the subsequent recovery data set, precluding analytical interpretation of that portion of the data. The effect in screen 1, on the other hand, was more dramatic with gas buildup beneath the upper packer apparently forcing the water level down to the pump intake, causing the discharge rate to decline precipitously and forcing premature termination of the test as described below.

R-52 Screen 1 Testing

The two screens were tested in reverse order, with screen 1 testing occurring after screen 2 testing. Screen 1 was tested from April 29 to May 3, 2010. After filling the drop pipe on April 29, testing began with brief trial pumping on April 30 followed by an attempted 24-h constant-rate pumping test that was started on May 1. The intended 24-h test was interrupted when air interfered with pump operation. After a 4.5-h shutdown period, pumping was resumed. Following shutdown of the 24-h test on May 2, recovery/background data were recorded for 1 d until May 3.

Trial testing of screen 1 began at 8:00 a.m. on April 30 at a discharge rate of 4.2 gallons per minute (gpm) and continued for 60 min until 9:00 a.m. Recovery data were recorded for 60 min until 10:00 a.m. when trial 2 pumping began at a discharge rate of 4.2 gpm. Following shutdown at 11:00 a.m., trial 2 recovery data were collected for 1260 min until 8:00 a.m. on May 1.

At 8:00 a.m. on May 1, the 24-h pumping test was initiated at a discharge rate of 4.2 gpm. After about 1 h, the discharge rate declined to less than 4 gpm and fluctuated somewhat over the next 14 h. At that point the rate declined rapidly to near zero forcing termination of the test at 11:30 p.m. After 4.5 h of water-level equilibration, the test was restarted at a discharge rate of 3.3 gpm at 4:00 a.m. on May 2 and continued for 4 h until 8:00 a.m. Following shutdown, recovery data were recorded for 1440 min until 8:00 a.m. on May 3 when the pump was pulled from the well.

R-52 Screen 2 Testing

Well R-52 screen 2 was tested initially from April 20 to 25, 2010. After filling the drop pipe on April 20, testing began with brief trial pumping on April 21, followed by background data collection, and then a 24-h constant-rate pumping test that began on April 22.

Two trial tests were conducted on April 21. Trial 1 was conducted at a discharge rate of 7.9 gpm for 60 min from 8:00 to 9:00 a.m. and was followed by 60 min of recovery until 10:00 a.m. Trial 2 was conducted for 60 min from 10:00 to 11:00 a.m. at a rate of 10.8 gpm. Following shutdown, recovery data were recorded for 1260 minutes until 8:00 a.m. on April 22.

At 8:00 a.m. on April 22, the 24-h pumping test was begun at a rate of 7.9 gpm. Pumping continued for 1440 min until 8:00 a.m. on April 23. Following shutdown, recovery/background measurements were recorded for 2880 min until 8:00 a.m. on April 25 when the pump was tripped out of the well.

Inspection of the data from the screen 2 testing showed a water-level rise in screen 1 during each of the pumping periods. The anomaly was diagnosed as a leak from the drop pipe into screen 1 caused by an O-ring seal failure at the top of the packer where the submersible pump wires pass through the drop pipe. The resulting water-level rise in screen 1 obscured the hydraulic response to pumping screen 2.

Because of this difficulty, the O-ring seals at the packer pass-through were replaced, and a supplemental pumping test was conducted on screen 2 on May 4 in an attempt to measure the true screen 1 response to pumping screen 2. Pumping was performed for 5 h from 7:00 a.m. to 12:00 p.m. at a discharge rate of 18.7 gpm. Unfortunately, the O-ring seals failed a second time, obscuring the sought response in screen 1.

E-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 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 R-52, have utilized nonvented transducers. These devices only 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 the Technical Area 54 (TA-54) tower site from Waste and Environmental Services Division-Environmental Data and Analysis (WES-EDA). The TA-54 measurement location is at an elevation of 6548 ft amsl, whereas the wellhead elevation is at 6883.04 ft amsl. The static water level in R-52 was 1017.96 ft below land surface, making the water-table elevation 5865.08 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-52.

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

$$P_{WT} = P_{TA54} \exp\left[-\frac{g}{3.281R}\left(\frac{E_{R-52} - E_{TA54}}{T_{TA54}} + \frac{E_{WT} - E_{R-52}}{T_{WELL}}\right)\right]$$

Equation E-1

where, P_{WT} = barometric pressure at the water table inside R-52

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

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

R = gas constant, in J/kg/degree kelvin (287.04 J/kg/degree kelvin)

$E_{R\text{-}52}$ = land surface elevation at R-52 site, in feet (6883.04 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-52, in feet (5865.08 ft)

T_{TA54} = air temperature near TA-54, in degrees kelvin (assigned a value of 49.2 degrees Fahrenheit, or 282.7 degrees kelvin)

T_{WELL} = air temperature inside R-52, in degrees kelvin (assigned a value of 66.4 degrees Fahrenheit, or 292.3 degrees kelvin)

This formula is an adaptation of an equation WES-EDA 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 before data analysis.

E-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 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 E-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, there can be an additional storage contribution from the filter pack around the screen. 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 E-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 E-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 approach was largely successful in the R-52 pumping test effort, with the exception of some of the recovery data from screen 2 as mentioned above.

E-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:

$$s = \frac{114.6Q}{T} W(u) \qquad \textbf{Equation E-4}$$

where,

$$W(u) = \int_u^{\infty} \frac{e^{-x}}{x} dx \qquad \textbf{Equation E-5}$$

and

$$u = \frac{1.87r^2 S}{Tt} \qquad \textbf{Equation E-6}$$

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:

$$T = \frac{114.6Q}{s} W(u) \qquad \textbf{Equation E-7}$$

$$S = \frac{Tut}{2693r^2} \qquad \textbf{Equation E-8}$$

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:

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

Equation E-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 the following:

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

Equation E-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 E-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

$$\beta = \sqrt{\frac{K_z}{K_r}} \frac{n\pi r}{b} \quad . \qquad \textbf{Equation E-12}$$

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

E-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:

$$T = \frac{264Q}{\Delta s} \qquad \textbf{Equation E-13}$$

The recovery data are particularly useful compared with 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.

E-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 not known, 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:

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

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

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

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). The screen 1 zone was treated as unconfined in this analysis, while the screen 2 zone was considered confined. Arbitrary storage coefficient values of 0.10 and 5×10^{-4} were used for the calculations for screen 1 and screen 2, respectively. The 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. Because locations of aquitards were not identified, an arbitrary thickness value of 100 ft was assigned to each zone for the purpose of these calculations. For partially penetrating conditions, the calculations are not particularly sensitive to the choice of aquifer thickness because sediments far above or below the screen typically contribute little flow.

E-7.0 BACKGROUND DATA ANALYSIS

Background aquifer pressure data collected during the R-52 tests were plotted along with barometric pressure to determine the barometric effect on water levels.

Figure E-7.0-1 shows aquifer pressure data collected from R-52 screen 1 during the screen 1 pumping 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-52 data are referred to in the figure as the “apparent hydrograph” because the measurements reflect the sum of water pressure and barometric pressure recorded using a nonvented pressure transducer. The times of the pumping periods for the R-52 screen 1 pumping tests are included on the figure for reference. R-52 screen 1 showed no significant pressure change in response to barometric pressure fluctuations, suggesting a barometric efficiency near 100%.

Figure E-7.0-2 shows aquifer pressure data collected from R-52 screen 2 during the screen 1 pumping test period. Portions of the hydrograph had a strikingly similar shape to the barometric pressure curve. However, as described below, subsequent monitoring of screen 2 (during the screen 2 testing period) showed a flat hydrograph response, belying a barometric relationship. The fluctuations in the apparent hydrograph in Figure E-7.0-2 were likely responses to pumping screen 1. Overall, it appeared that pumping screen 1 at 4.2 gpm induced about 0.1 ft of drawdown (plus or minus) in screen 2.

Figure E-7.0-3 shows aquifer pressure data collected from R-52 screen 1 during the screen 2 pumping 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. As observed during the screen 1 test period, fluctuations in barometric pressure had negligible effect on total aquifer pressure, indicating a high barometric efficiency. The hydrograph showed an abrupt water-level rise in screen 1 each time screen 2 was pumped. The rise in water level observed in each pumping test was attributable to a faulty O-ring seal at the top of the packer allowing drop pipe water to leak into screen 1. During the 24-h test, the data showed the rapid water-level rise, followed by a gradual decline—presumably a drawdown response in screen 1 to pumping screen 2. The superimposition of water-level rise caused by the leaky O-ring and the dynamic time-varying drawdown caused by pumping screen 2 made it impossible to determine the respective contributions of the two effects. The net effect on water levels showed that the water-level rise caused by the leaky seal was about 0.2 ft greater than the drawdown caused by pumping screen 2.

Figure E-7.0-4 shows aquifer pressure data collected from R-52 screen 2 during the screen 2 pumping test period. As stated previously, there was no discernable change in aquifer pressure in response to barometric pressure changes, implying a high barometric efficiency. A diurnal fluctuation having a magnitude of about 0.02 ft was evident in the data plot, likely an Earth-tide effect.

Figure E-7.0-5 shows the apparent hydrograph for screen 1 recorded during the 5-h supplemental pumping test on screen 2. The supplemental test was conducted at an increased discharge rate—18.7 gpm compared with 7.9 gpm during the original 24-h test. At the greater flow rate, the induced drawdown in screen 1 was greater than before. In fact, at the time of pump shutoff, the net rise in water level (rise caused by leaky O-ring seal minus induced drawdown from pumping screen 2) was zero. At the end of the test, the water level in screen 1 was still declining, so if the test had continued for 24 h, there likely would have been a net decline in water level. Recall that when screen 2 was pumped at 7.9 gpm for 24 h, there was a net rise of 0.2 ft. Pumping at 18.7 gpm (a rate increase of 10.8 gpm) resulted in a net change in water level of zero after 5 h, and it appeared that it would have caused a net decline in water level had the test continued for 24 h. Thus, the incremental discharge rate of 10.8 gpm in screen 2 caused an incremental drawdown in screen 1 of 0.2 ft and would have caused more than this had pumping continued for 24 h. Thus, it could be concluded that pumping screen 2 at 10.8 gpm for 24 h would cause more than 0.2 ft of drawdown in screen 1.

Hydrograph data from nearby well R-37 (about 860 ft away) were downloaded to check for a possible pumping response to the R-52 tests. Examination was limited to screen 2, the screen completed in the regional aquifer. Figure E-7.0-6 shows data collected from R-37 screen 2 during the pumping test period.

Because the barometric pressure–induced fluctuations in the hydrograph were large, it was necessary to correct the water-level data by removing the barometric effect. This was done using Barometric and Earth Tide Response Correction (BETCO) software—a mathematically complex correction algorithm that uses regression deconvolution (Toll and Rasmussen 2007, 104799) to modify the data. The BETCO correction not only removes barometric pressure effects, but can remove Earth-tide effects as well. The BETCO barometric corrected data are included in the data plot in Figure E-7.0-6.

Examination of the corrected hydrograph for R-37 screen 2 showed no response to any of the R-52 pumping tests.

E-8.0 WELL R-52 SCREEN 1 DATA ANALYSIS

This section presents the data obtained from the R-52 screen 1 pumping tests and the results of the analytical interpretations. Data are presented for drawdown and recovery from trial 1, trial 2, and the 24-h constant-rate pumping test.

E-8.1 Well R-52 Screen 1 Trial 1 Test

Figure E-8.1-1 shows a semilog plot of the drawdown data collected from the 60-min trial 1 test on screen 1 at a discharge rate of 4.2 gpm. The transmissivity estimated from the plot was 3200 gpd/ft. Based on the screen length of 20.5 ft, the computed hydraulic conductivity was 156 gpd/ft^2, or 20.9 ft/d.

Figure E-8.1-2 shows the recovery data collected following shutdown of the trial 1 pumping test. The data suggested a transmissivity of 2770 gpd/ft and a hydraulic conductivity of 135 gpd/ft^2, or 18.1 ft/d. Toward the end of the recovery period, the slope of the data trace flattened somewhat, likely a response to partial penetration effects (vertical growth of the cone of impression). Other possible causes included (1) a lateral increase in transmissivity, (2) leakage from sediments above and/or below the screened interval, and (3) delayed yield associated with drainage and movement of the phreatic surface. It is possible that a combination of all of these effects could have caused the observed effect.

E-8.2 Well R-52 Screen 1 Trial 2 Test

Figure E-8.2-1 shows a semilog plot of the drawdown data collected from the 60-min trial 2 test on screen 1 at a discharge rate of 4.2 gpm. The transmissivity estimated from the plot was 2890 gpd/ft. Based on the screen length of 20.5 ft, the computed hydraulic conductivity was 141 gpd/ft^2, or 18.8 ft/d.

Figure E-8.2-2 shows the recovery data collected following shutdown of the trial 2 pumping test. The data suggested a transmissivity of 2790 gpd/ft and a hydraulic conductivity of 136 gpd/ft^2, or 18.2 ft/d.

Again, the late recovery data showed a substantial reduction in slope as a function of partial penetration effects, heterogeneity, leakage, and/or delayed yield.

E-8.3 Well R-52 Screen 1 24-h Constant-Rate Test

Figure E-8.3-1 shows a semilog plot of the drawdown data collected from the 24-h constant-rate pumping test conducted at 10.5 gpm. The analysis shown on the graph for data up to 60 min into the test suggested a screen interval transmissivity of 3270 gpd/ft and a hydraulic conductivity of 160 gpd/ft^2, or 21.3 ft/d.

The presence of air or gas in the pumped water affected the pumping test. About 1 hr into the pumping test, there was a significant change in pump and aquifer performance. The discharge rate declined to about 3.3 gpm and, around the same time, the drawdown increased. It is possible that gas buildup in the formation pores caused a transient reduction in hydraulic conductivity, increasing the drawdown.

About 200 min into the pumping test, the discharge rate increased slightly, to about 3.6 gpm, and the drawdown declined. Again, these chaotic effects were likely associated with transient gas content in the formation pores and pumped groundwater.

A little less than 15 h into the test, the discharge rate began plummeting and, as a result, the drawdown declined accordingly. At a pumping time of 15.5 h, the rate declined to near zero, and the pump was shut off at 11:30 p.m.

After an equilibration period of 4.5 h, pumping was resumed at 4:00 a.m. at a discharge rate of 3.3 gpm and continued until 8:00 a.m. Figure E-8.3-2 shows the resulting data plot supporting a transmissivity calculation of 2890 gpd/ft and a hydraulic conductivity of 141 gpd/ft^2, or 18.8 ft/d. About 2.5 h into the pumping period, there was an abrupt rise in water level (drawdown reduction). The discharge rate remained reasonably stable during this period, so this effect was likely a response to a transient change in gas content in the formation pores and resultant hydraulic conductivity.

Figure E-8.3-3 shows the recovery data collected following shutdown of the final portion of the 24-h constant-rate pumping test. As indicated on the plot, the transmissivity computed from the line of fit was 2520 gpd/ft, corresponding to a hydraulic conductivity of 123 gpd/ft^2, or 16.4 ft/d.

The late recovery data showed a significant reduction in slope. Figure E-8.3-4 shows an analysis of the late-time recovery slope, suggesting a transmissivity value of 10,600 gpd/ft. This could have reflected the transmissivity of an unknown thickness of sediment extending above and/or below the screened interval. It is also possible that the transmissivity calculation is meaningless and that the slope of that portion of the data set was an artifact of the combination of possible effects cited previously.

E-8.4 Well R-52 Screen 1 Specific Capacity Data

Specific capacity data were used along with well geometry to estimate a lower-bound transmissivity value for the permeable zone penetrated by R-52 screen 1. This was done to provide a frame of reference for evaluating the foregoing analyses.

During the first portion of the 24-h pumping test, the discharge rate was 3.6 gpm after 885 min of pumping, with a resulting drawdown of 1.4 ft for a specific capacity of 2.6 gpm/ft. In addition to specific capacity and pumping time, other input values used in the calculations included a storage coefficient value of 0.1, a borehole radius of 0.62 ft (inferred from the volume of filter pack required to backfill the screen zone), a screen length of 20.5 ft, and an arbitrary saturated thickness of 100 ft.

Applying the Brons and Marting method to these inputs yielded a lower-bound hydraulic conductivity value of 105 gpd/ft^2, or 14.1 ft/d. The average hydraulic conductivity value from the foregoing pumping test analyses was 141 gpd/ft^2, or 18.9 ft/d. Thus, the lower-bound value was consistent with the pumping test results and suggested a well efficiency around 75%.

E-9.0 WELL R-52 SCREEN 2 DATA ANALYSIS

This section presents the data obtained from the R-52 screen 2 pumping tests and the results of the analytical interpretations. Data are presented for drawdown and recovery from trial 1, trial 2, and the 24-h constant-rate pumping test.

E-9.1 Well R-52 Screen 2 Trial 1

Figure E-9.1-1 shows a semilog plot of the screen 2 drawdown data collected from trial 1 at a discharge rate of 7.9 gpm. During the first 35 s of pumping, the water level declined rapidly (to about double the eventual drawdown level) and then rose abruptly. The leaky O-ring seal above the upper packer had allowed a portion of the drop pipe beneath the nearest check valve to drain before the start of the pumping test. This meant that the pump started against substantially reduced head and, therefore, produced at a much higher rate until the void in the drop pipe was filled. Once this occurred, the pump operated against greater head (the full height of the drop pipe from the pumping level to the surface discharge elevation), and the discharge rate declined to the adjusted value of 7.9 gpm.

The transmissivity determined from the line of fit in Figure E-9.1-1 was 1530 gpd/ft for the 10-ft-long screened interval, making the estimated average hydraulic conductivity 153 gpd/ft^2, or 20.5 ft/d.

Figure E-9.1-2 shows the recovery data collected following shutdown of the trial 1 pumping test. The transmissivity estimated from the very early data was 2020 gpd/ft, making the computed hydraulic conductivity 202 gpd/ft^2, or 27.0 ft/d. The subsequent data showed a slight slope increase, with a calculated transmissivity of 1410 gpd/ft, and a hydraulic conductivity of 141 gpd/ft^2, or 18.9 ft/d.

The small slope change suggested slightly heterogeneous conditions, with the hydraulic conductivity of the sediments nearest the borehole being greatest and a slight reduction through the greater area away from the well. Note that the drawdown data did not show the earlier slope because that portion of the data set was obscured by the refilling of the drop pipe.

E-9.2 Well R-52 Screen 2 Trial 2

Figure E-9.2-1 shows a semilog plot of the drawdown data collected from the trial 2 test at a discharge rate of 10.8 gpm. The initial response reflected the refilling of the drained portion of the drop pipe. The transmissivity value computed from the line of fit shown on the graph was 1560 gpd/ft, making the average hydraulic conductivity of the screened interval 156 gpd/ft^2, or 20.9 ft/d.

Figure E-9.2-2 shows the recovery data collected following shutdown of the trial 2 pumping test. The transmissivity estimated from the early data was 2000 gpd/ft, making the computed hydraulic conductivity adjacent to the borehole 200 gpd/ft^2, or 26.7 ft/d. The subsequent data showed a slope increase, as was observed in trial 1, with a calculated transmissivity of 1370 gpd/ft and hydraulic conductivity of the more distant sediments of 137 gpd/ft^2, or 18.3 ft/d.

The first couple of data points on the recovery plot fell below the line of fit, likely a modest storage effect associated with accumulation of air in the filter pack or casing beneath the inflatable packer. The water produced from screen 2 was exceptionally aerated during all of the pumping tests.

The very late recovery data showed a flat slope, likely a reflection of partial penetration effects (vertical growth of the cone of impression), but also possibly an indication of lateral heterogeneity and/or leakage effects.

E-9.3 Well R-52 Screen 2 24-h Constant-Rate Test

Figure E-9.3-1 shows a semilog plot of the drawdown data collected from the 24-h constant-rate pumping test conducted at 7.9 gpm. Again, the leaky O-ring seal allowed drainage of the bottom portion of the drop pipe overnight before the 24-h test and, as a result, the early data reflected a substantially greater initial discharge rate. Analysis of the subsequent data showed a screen interval transmissivity of 1470 gpd/ft and a hydraulic conductivity of 147 gpd/ft^2, or 19.7 ft/d.

About 1 hr into the test, the drawdown curve flattened significantly. The latest data are shown on the expanded-scale plot in Figure E-9.3-2, revealing a transmissivity of 7700 gpd/ft. This may represent the actual transmissivity of an unknown thickness of sediment corresponding to the height of the cone of depression at that time, or may simply reflect a combination of features including partial penetration effects, heterogeneity, and/or leakage.

Figure E-9.3-3 shows the recovery data collected following shutdown of the 24-h constant-rate pumping test. As indicated on the plot, the transmissivity computed from the early data was 1850 gpd/ft with a corresponding hydraulic conductivity of 185 gpd/ft^2, or 24.7 ft/d. The subsequent data showed a transmissivity value of 1430 gpd/ft and a hydraulic conductivity of 143 gpd/ft^2, or 19.1 ft/d. Note that the first few data points fell beneath the early-time line of fit on the graph, suggesting a slight storage effect associated with air or gas in the groundwater.

Very late data showed continuing flattening of the recovery curve. Figure E-9.3-4 shows an expanded-scale plot of the late data with a corresponding transmissivity of 29,700 gpd/ft. It was not known if this was a true transmissivity or an artifact of a combination of the effects of vertical growth of the cone of depression, heterogeneity, and/or leakage effects from the overlying unconfined zone and attendant delayed yield influence.

E-9.4 Well R-52 Screen 2 Supplemental Test

Figure E-9.4-1 shows a semilog plot of the drawdown data collected from the 5-h supplemental pumping test conducted at 18.7 gpm. As indicated on the plot, the transmissivity computed from the early data was 1990 gpd/ft with a corresponding hydraulic conductivity of 190 gpd/ft^2, or 26.6 ft/d. The subsequent data showed a transmissivity value of 1320 gpd/ft and a hydraulic conductivity of 132 gpd/ft^2, or 17.6 ft/d.

Figure E-9.4-2 shows the recovery data collected following shutdown of the supplemental pumping test. The earliest data points fell beneath the line of fit shown on the graph, indicative of storage effects likely associated with air or gas in the well and groundwater. The subsequent line of fit led to a computed transmissivity of just 1150 gpd/ft—substantially less than the values obtained from all other analyses. This suggested that lingering storage effects continued to affect the data. The computed value was not considered representative of formation characteristics.

The very late recovery data from the supplemental test showed continuing flattening of the recovery curve. Figure E-9.4-3 shows an expanded-scale plot of the late data with a corresponding transmissivity of 26,300 gpd/ft. It was not known if this was a true transmissivity or an artifact of a combination of the effects of vertical growth of the cone of depression, heterogeneity, and/or leakage effects from the overlying unconfined zone and attendant delayed yield influence.

E-9.5 Well R-52 Screen 2 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-52 screen 2. This was done to provide a frame of reference for evaluating the foregoing analyses.

During the 24-h constant-rate pumping test, the discharge rate was 7.9 gpm after 1440 min of pumping, with a resulting drawdown of 7.64 ft for a specific capacity of 1.03 gpm/ft. In addition to specific capacity and pumping time, other input values used in the calculations included a storage coefficient value of 5×10^{-4}, a borehole radius of 0.72 ft (inferred from the volume of filter pack required to backfill the screen zone), a screen length of 10 ft, and an arbitrary saturated thickness of 100 ft.

Applying the Brons and Marting method to these inputs yielded a lower-bound hydraulic conductivity value of 75 gpd/ft^2, or 10.0 ft/d. The foregoing pumping test analyses yielded transmissivity values averaging about 1960 gpd/ft immediately adjacent to the well, with an average hydraulic conductivity of 196 gpd/ft^2, or 26.2 ft/d. Over a greater area around the well, the data showed an average transmissivity of 1440 gpd/ft and a hydraulic conductivity of 144 gpd/ft^2, or 19.3 ft/d. The lower-bound value was consistent with these results and implied a well efficiency of about 50%.

E-10.0 SUMMARY

Constant-rate pumping tests were conducted on R-52 screens 1 and 2. The tests were performed to gain an understanding of the hydraulic characteristics of the screen zones and the degree of interconnection between them. Numerous observations and conclusions were drawn from the tests as summarized below.

Aerated groundwater was produced from both screens 1 and 2 during the pumping tests. The gas content interfered with pump operation during some of the screen 1 tests and contributed storage effects in some of the screen 2 tests.

The static water level observed in screen 1 was 1.78 ft higher than that in screen 2, showing a downward hydraulic gradient and implying impermeable sediments separate the screened zones.

A comparison of barometric pressure and R-52 water-level data showed a high barometric efficiency, around 100%, for both screened zones.

Pumping screen 1 at 4.2 gpm for 1440 min caused about 0.1 ft of drawdown in screen 2. A leaky O-ring seal obscured the effect of pumping screen 2 on screen 1. However, it was determined that pumping screen 2 at 10.8 gpm would have caused more than 0.2 ft of drawdown in screen 1.

There was no discernable effect of pumping either of the R-52 screens in R-37 screen 2 located just over 1100 ft away.

Analysis of the screen 1 pumping tests showed an average hydraulic conductivity value of 141 gpd/ft^2, or 18.9 ft/d.

Screen 1 produced 3.6 gpm for 885 min with 1.4 ft of drawdown for a specific capacity of 2.6 gpm/ft. The lower-bound hydraulic conductivity computed from this information was 105 gpd/ft^2, or 14.1 ft/d, consistent with the pumping tests values and suggesting a screen zone efficiency of about 75%.

Analysis of the screen 2 pumping tests suggested a near-well hydraulic conductivity of 196 gpd/ft^2, or 26.2 ft/d, and a hydraulic conductivity over a broader area of 144 gpd/ft^2, or 19.3 ft/d.

Screen 2 produced 7.9 gpm for 1440 min with 7.64 ft of drawdown for a specific capacity of 1.03 gpm/ft. The lower-bound hydraulic conductivity computed from this information was 75 gpd/ft^2, or 10.0 ft/d, consistent with the pumping tests values and suggesting a screen-zone efficiency on the order of 50%.

E-11.0 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. This information is also included in text citations. ER IDs are assigned by the Environmental Programs Directorate's Records Processing Facility (RPF) and are used to locate the document at the RPF and, where applicable, in the master reference set.

Copies of the master reference set are maintained at the NMED Hazardous Waste Bureau and the 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)

Toll, N.J., and T.C. Rasmussen, January–February 2007. “Removal of Barometric Pressure Effects and Earth Tides from Observed Water Levels,” *Ground Water,* Vol. 45, No. 1, pp. 101–105. (Toll and Rasmussen 2007, 104799)

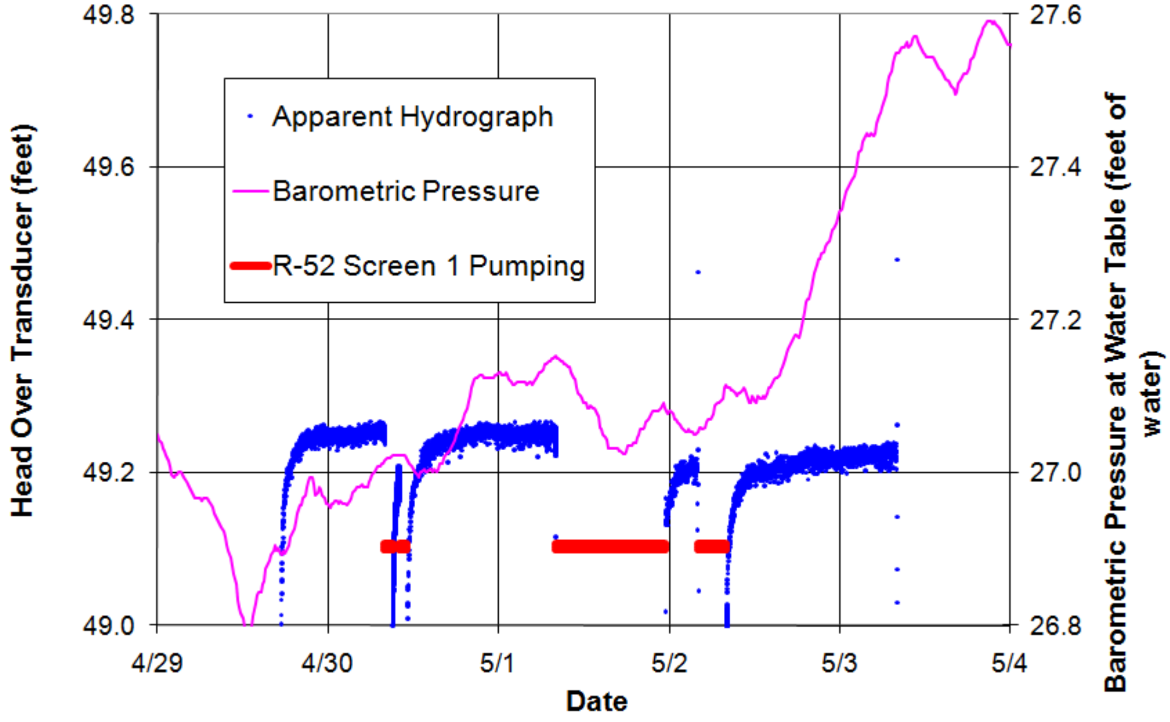


Figure E-7.0-1 Well R-52 screen 1 apparent hydrograph during screen 1 test

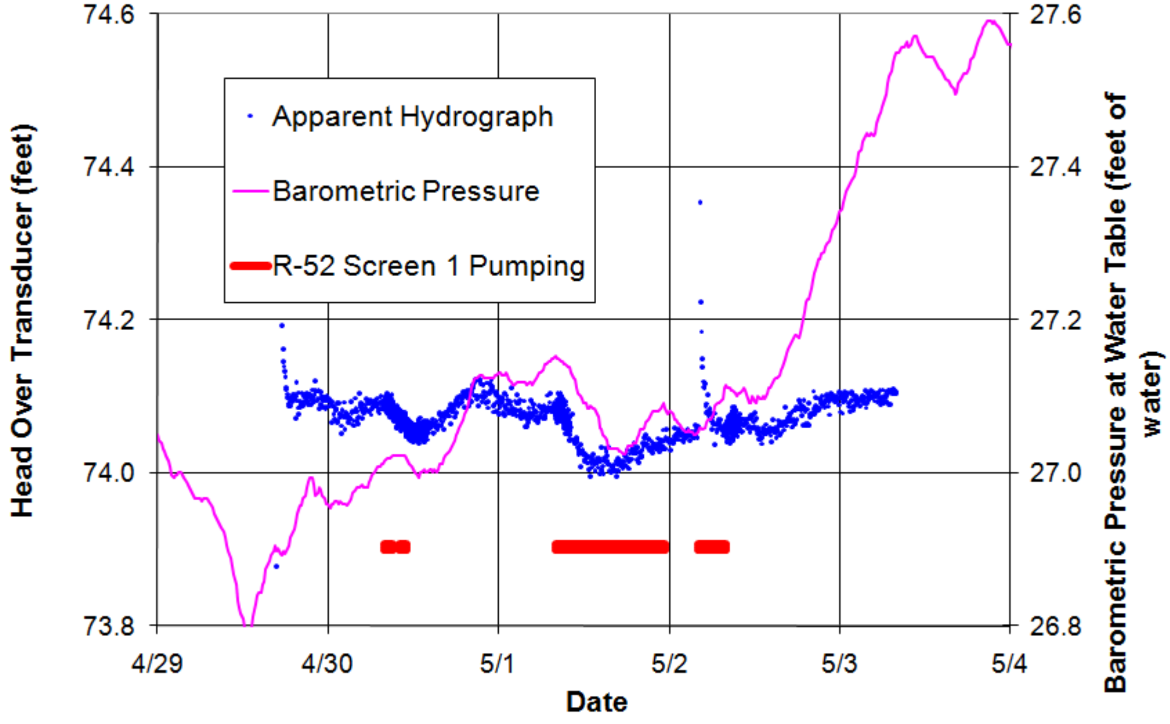


Figure E-7.0-2 Well R-52 screen 2 apparent hydrograph during screen 1 test

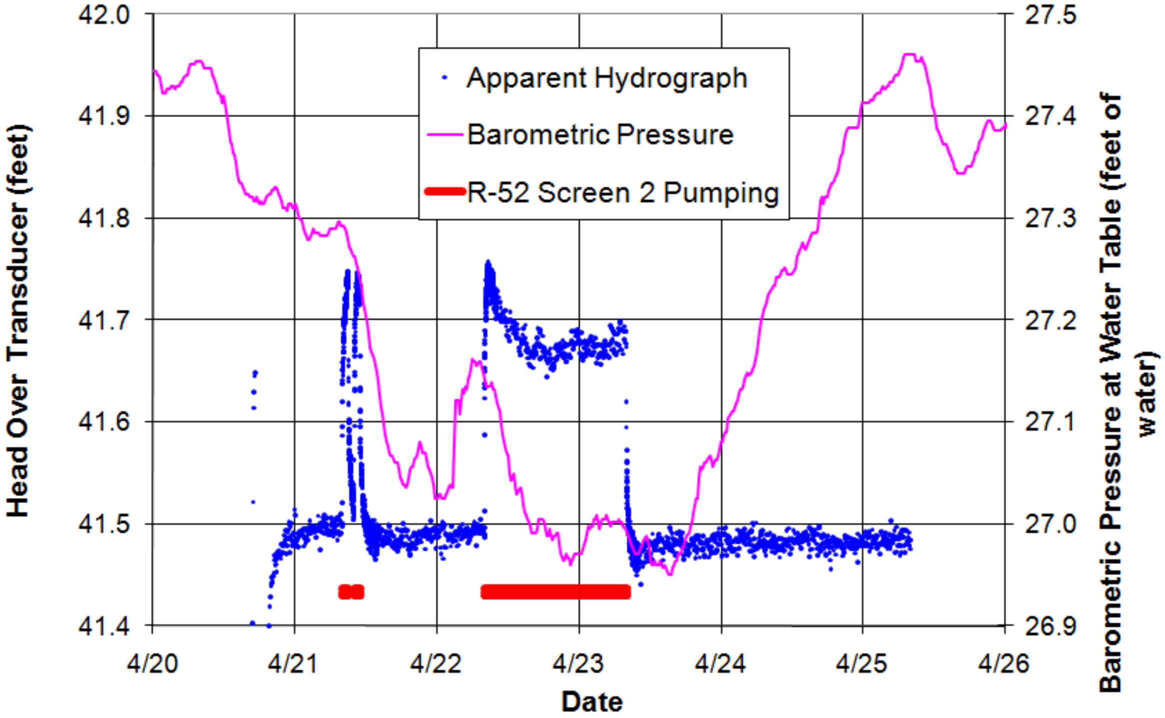


Figure E-7.0-3 **Well R-52 screen 1 apparent hydrograph during screen 2 test**

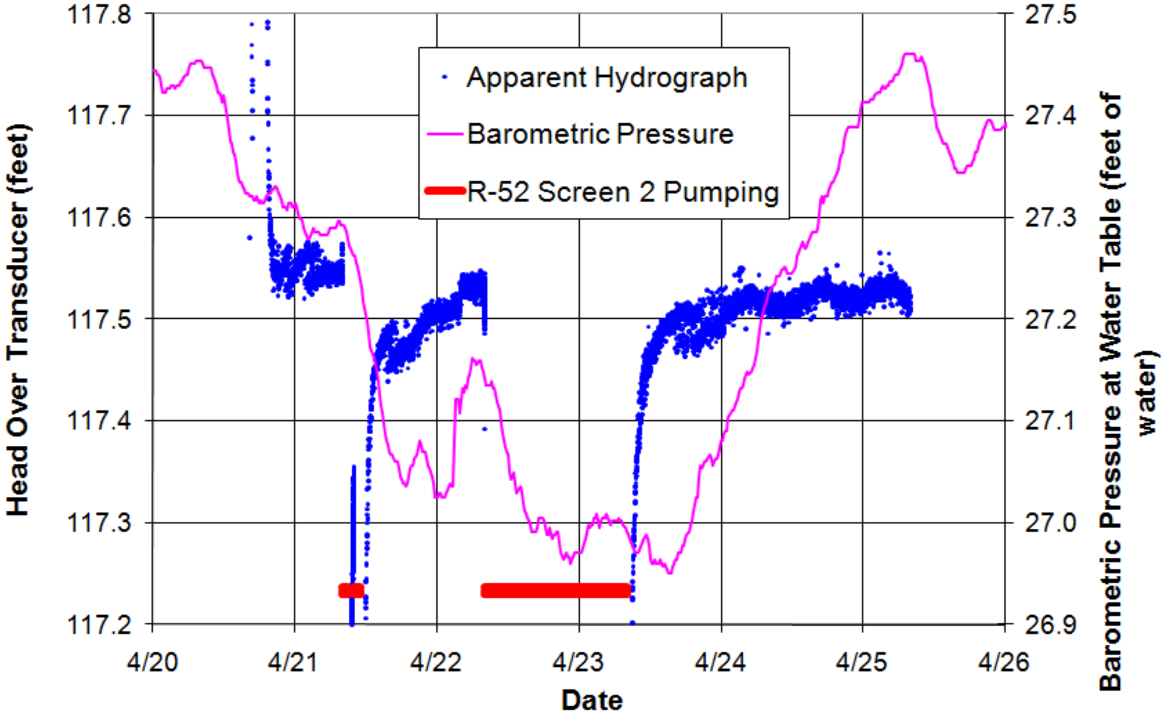


Figure E-7.0-4 **Well R-52 screen 2 apparent hydrograph during screen 2 test**

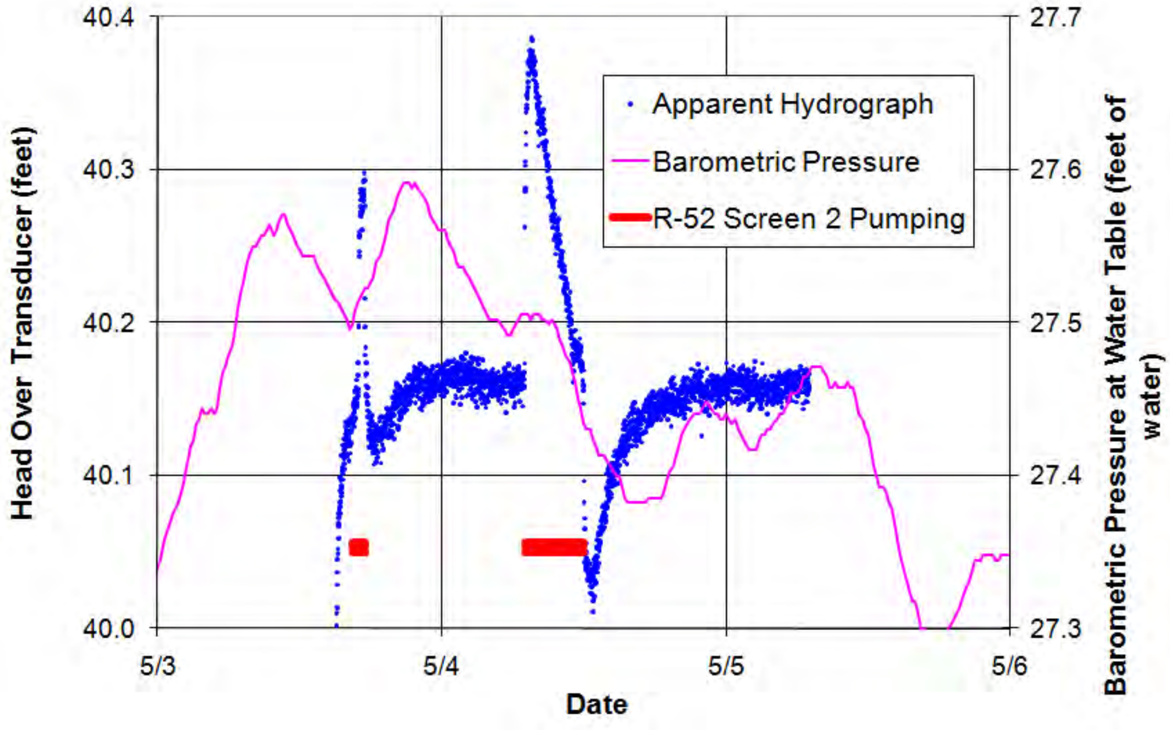


Figure E-7.0-5 Well R-52 screen 1 apparent hydrograph during screen 2 supplemental test

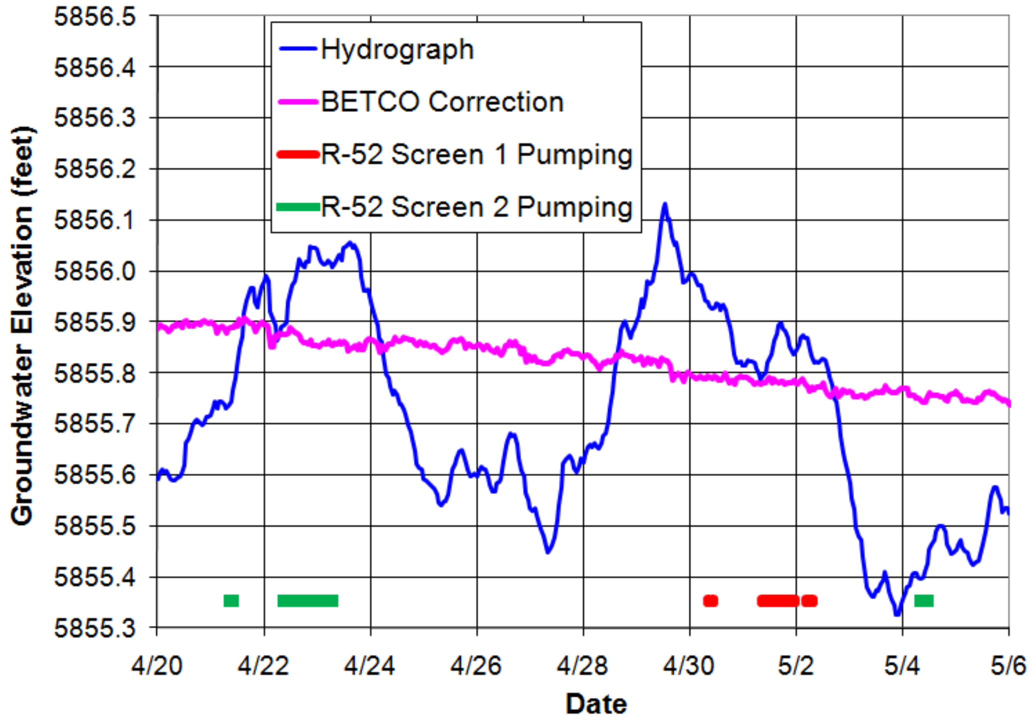


Figure E-7.0-6 Well R-37 screen 2 hydrograph

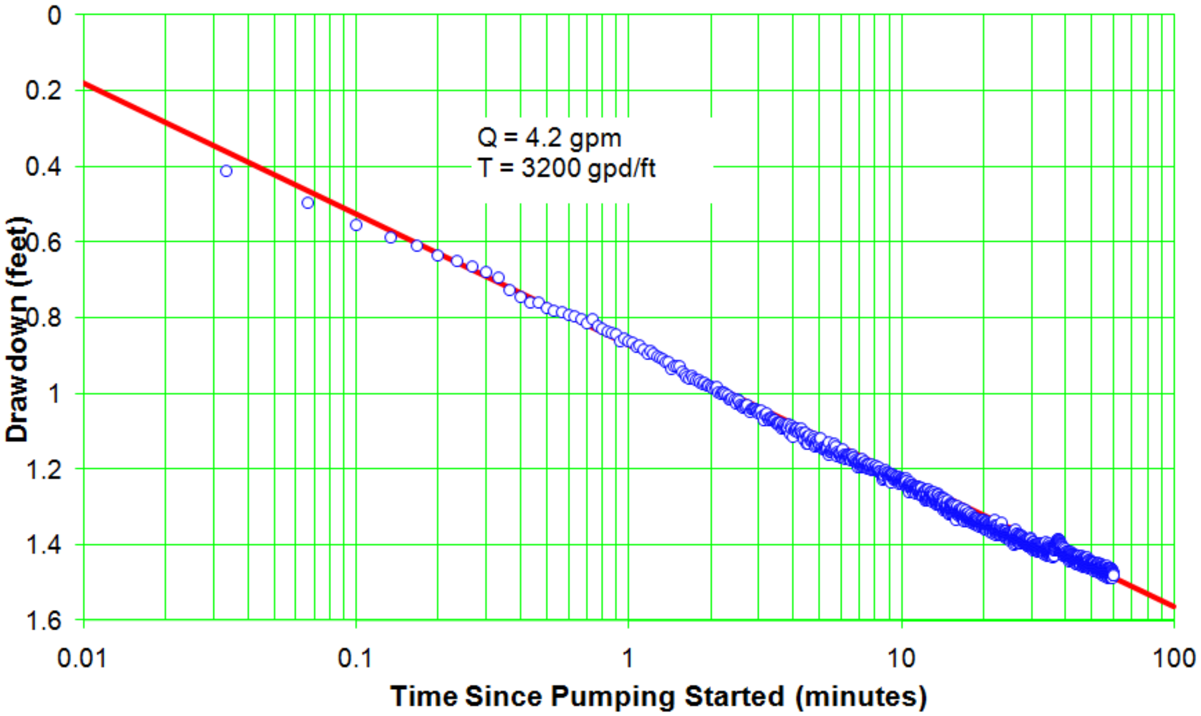


Figure E-8.1-1 Well R-52 screen 1 trial 1 drawdown

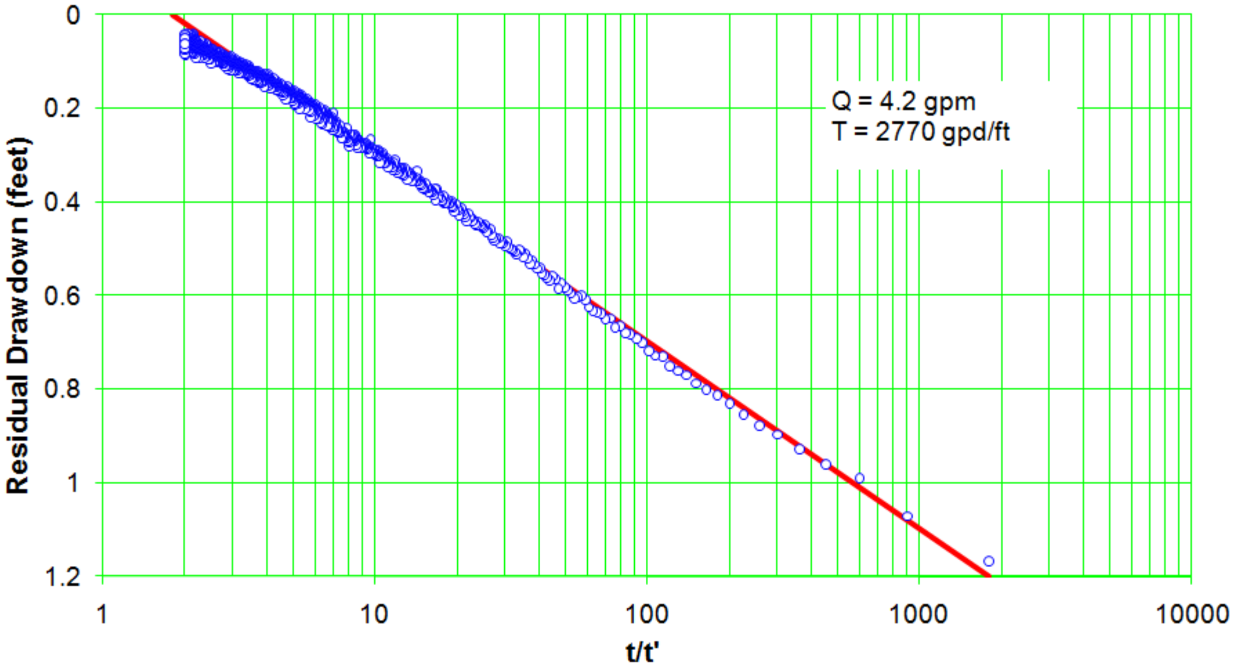


Figure E-8.1-2 Well R-52 screen 1 trial 1 recovery

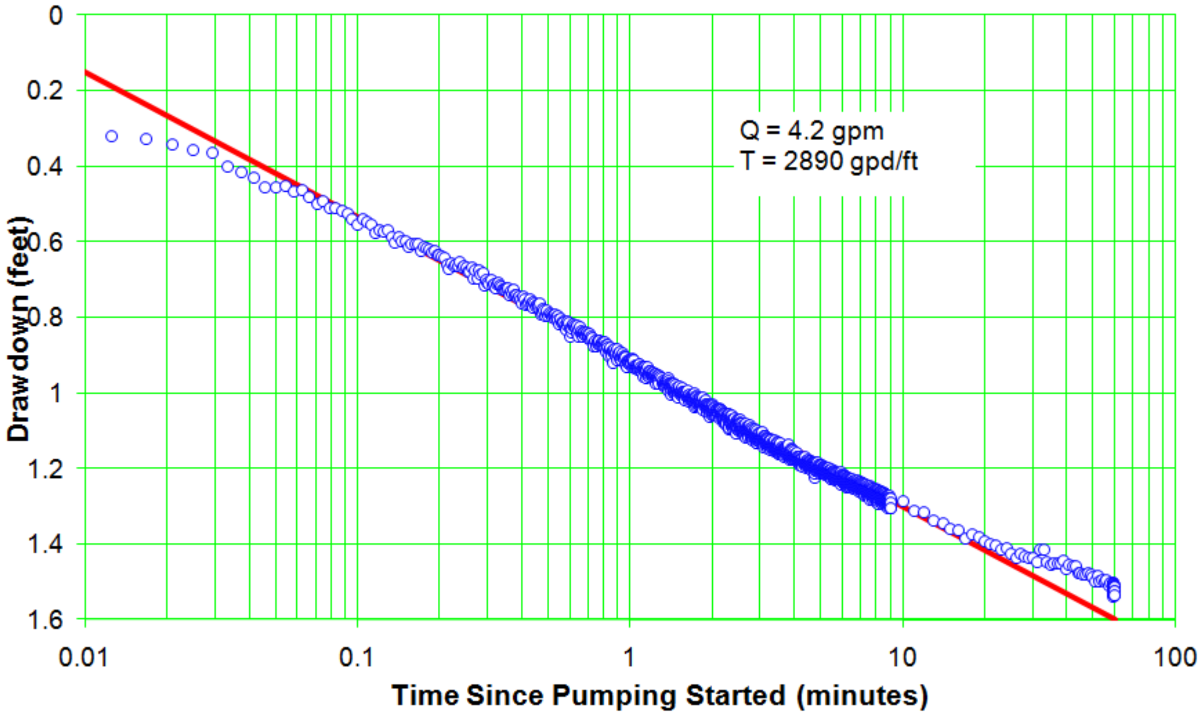


Figure E-8.2-1 **Well R-52 screen 1 trial 2 drawdown**

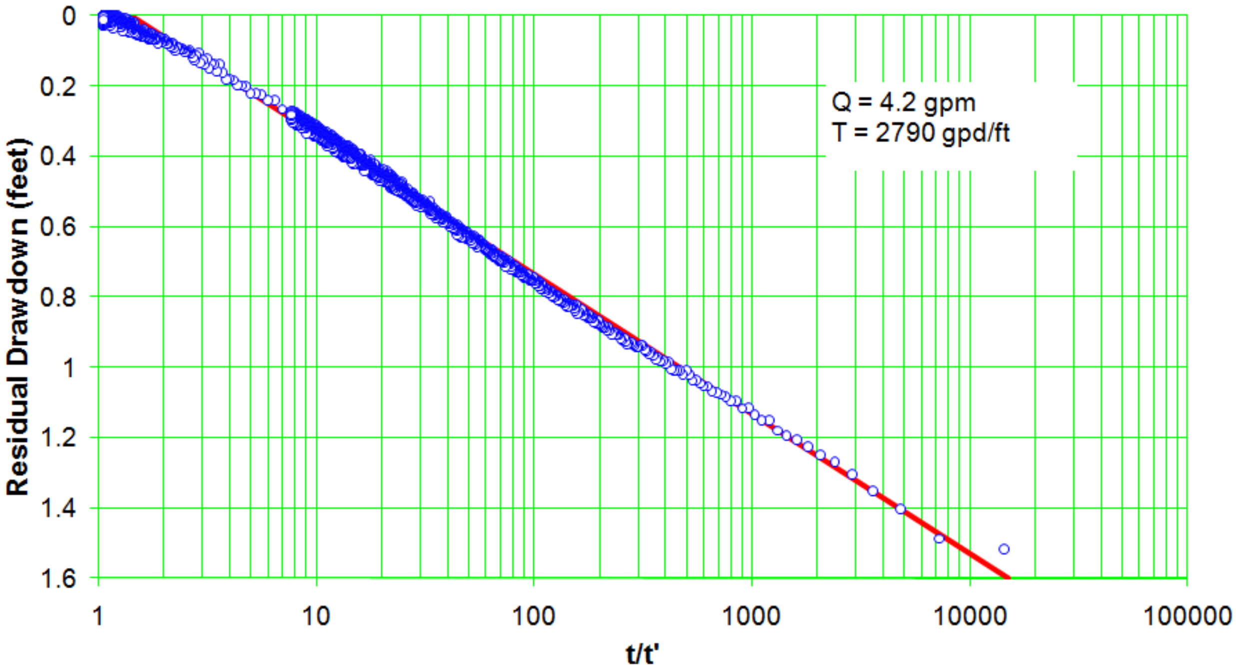


Figure E-8.2-2 **Well R-52 screen 1 trial 2 recovery**

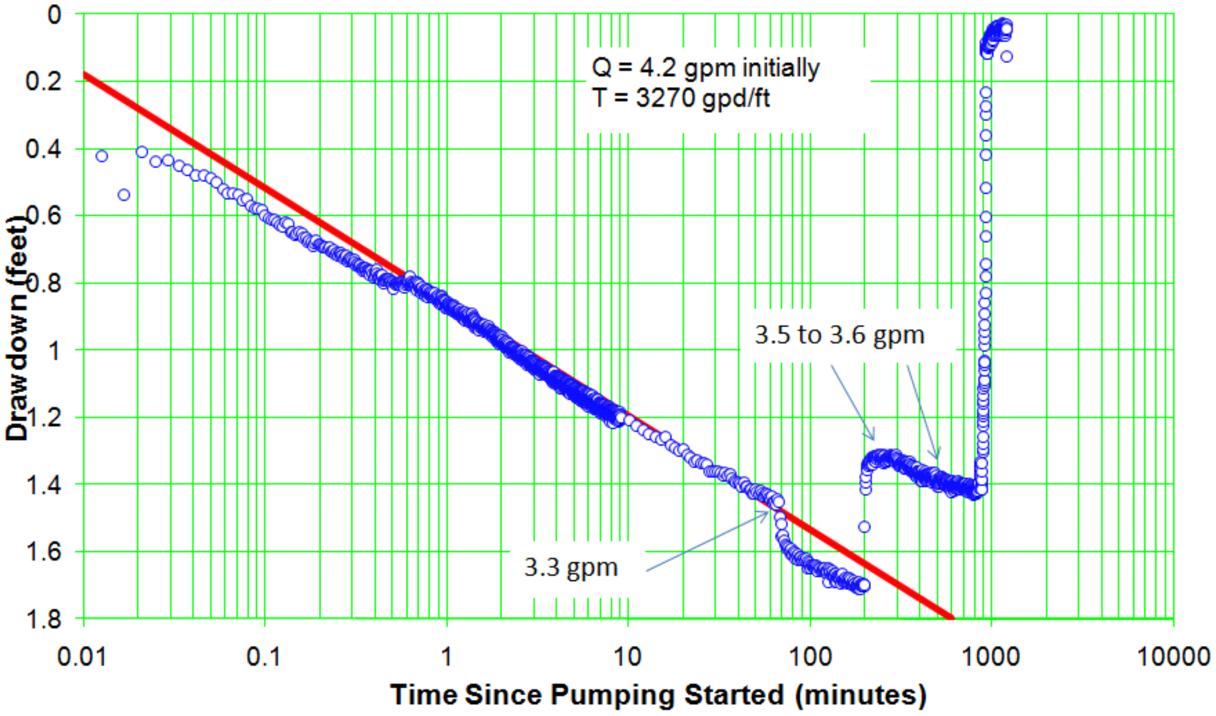


Figure E-8.3-1 Well R-52 screen 1 drawdown

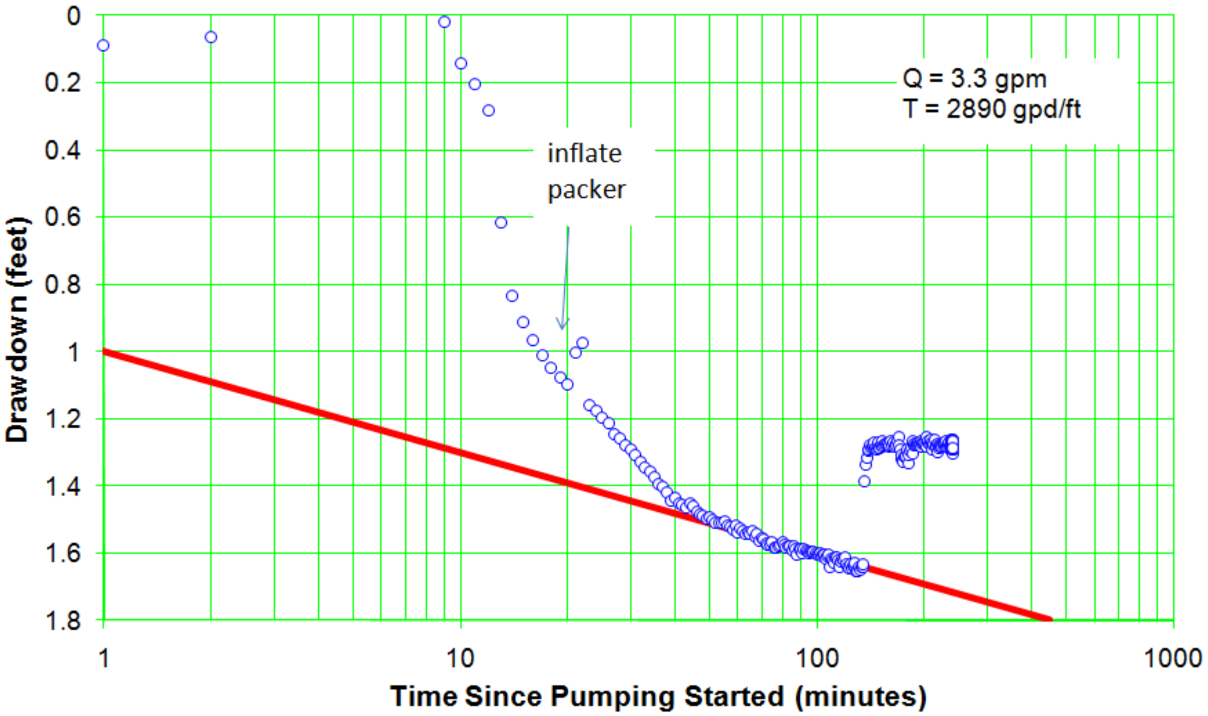


Figure E-8.3-2 Well R-52 screen 1 drawdown after restart

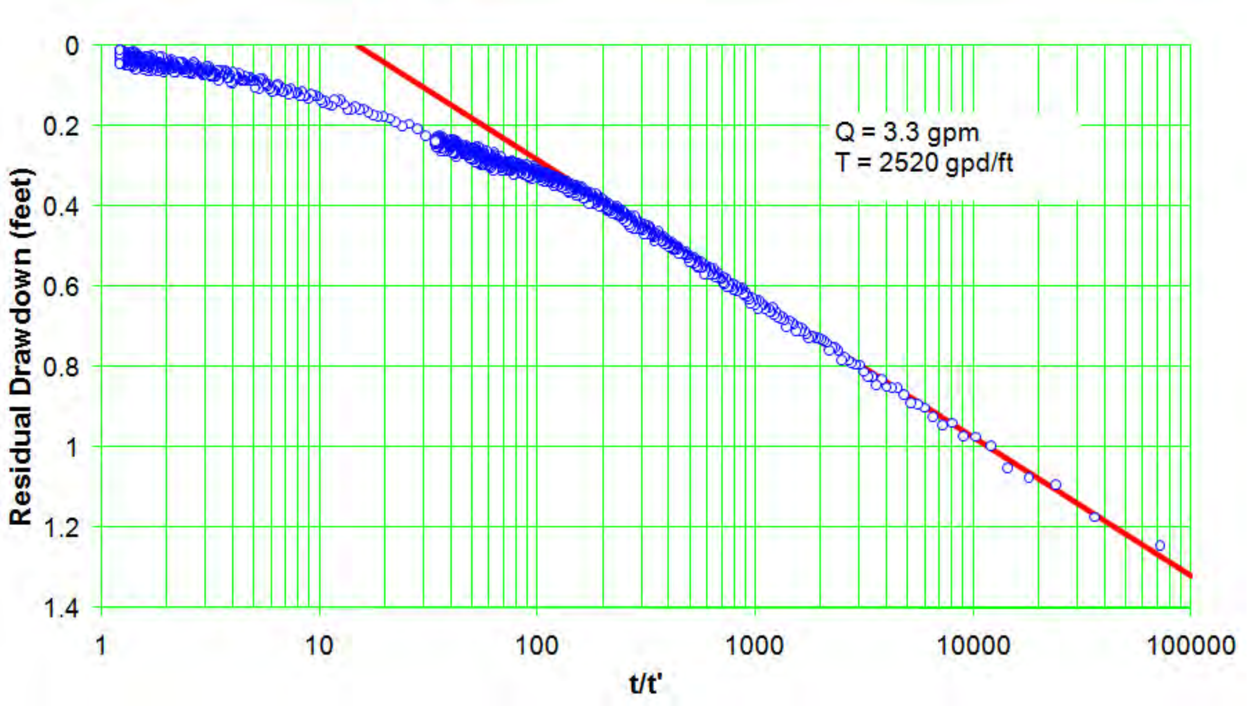


Figure E-8.3-3 Well R-52 screen 1 recovery

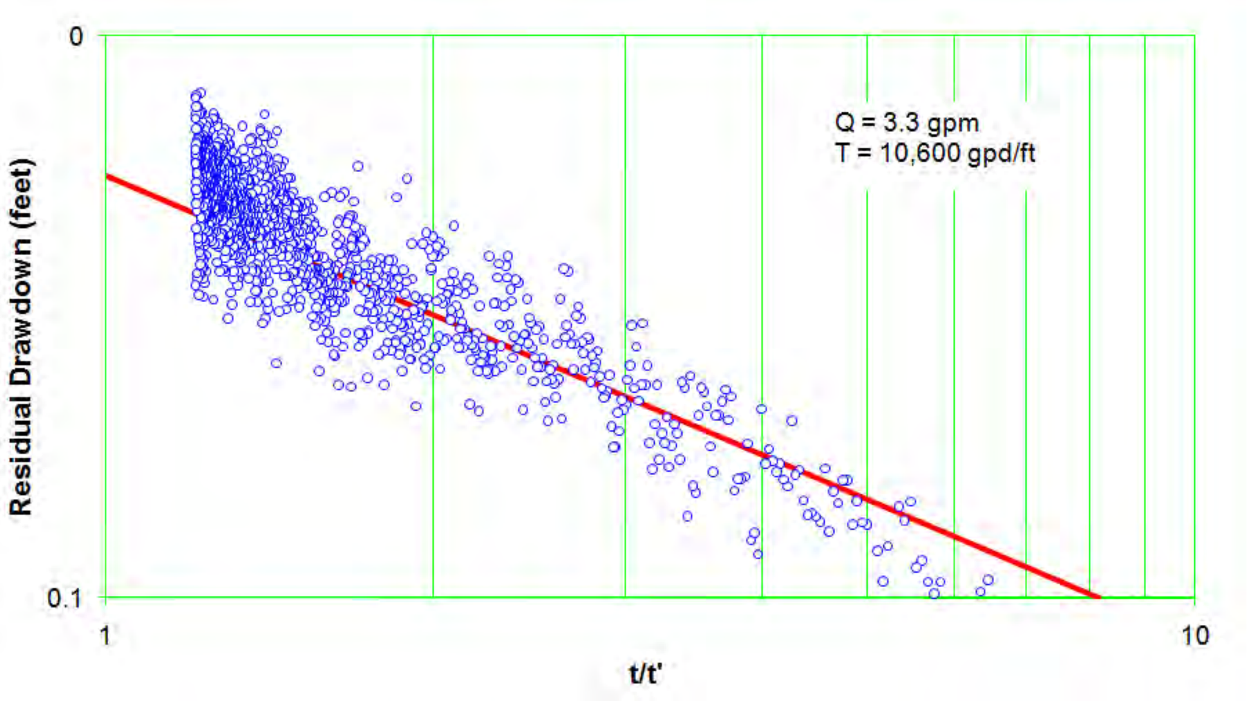


Figure E-8.3-4 Well R-52 screen 1 recovery—expanded scale

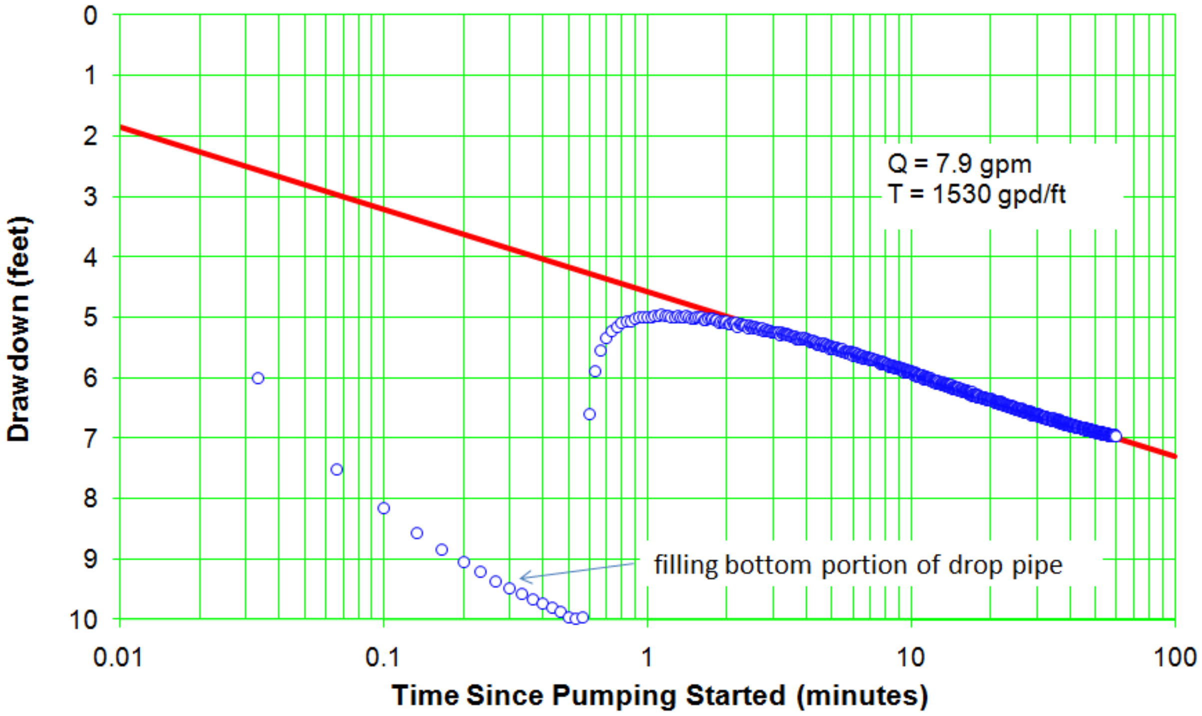


Figure E-9.1-1 **Well R-52 screen 2 trial 1 drawdown**

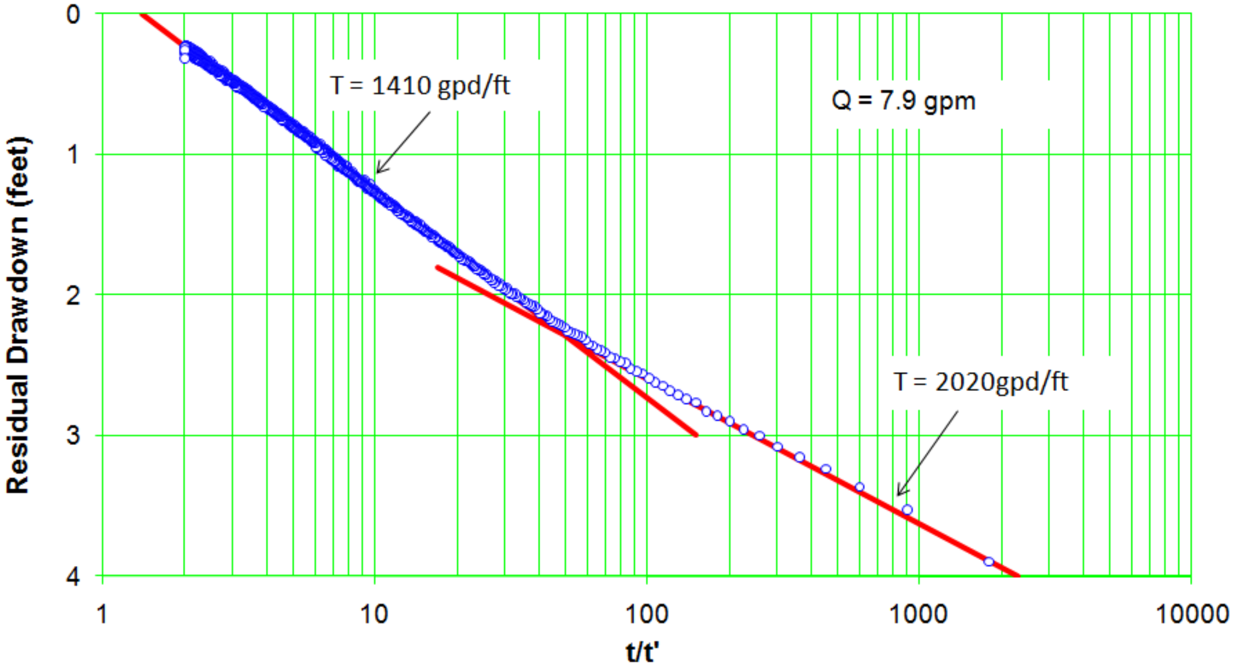


Figure E-9.1-2 **Well R-52 screen 2 trial 1 recovery**

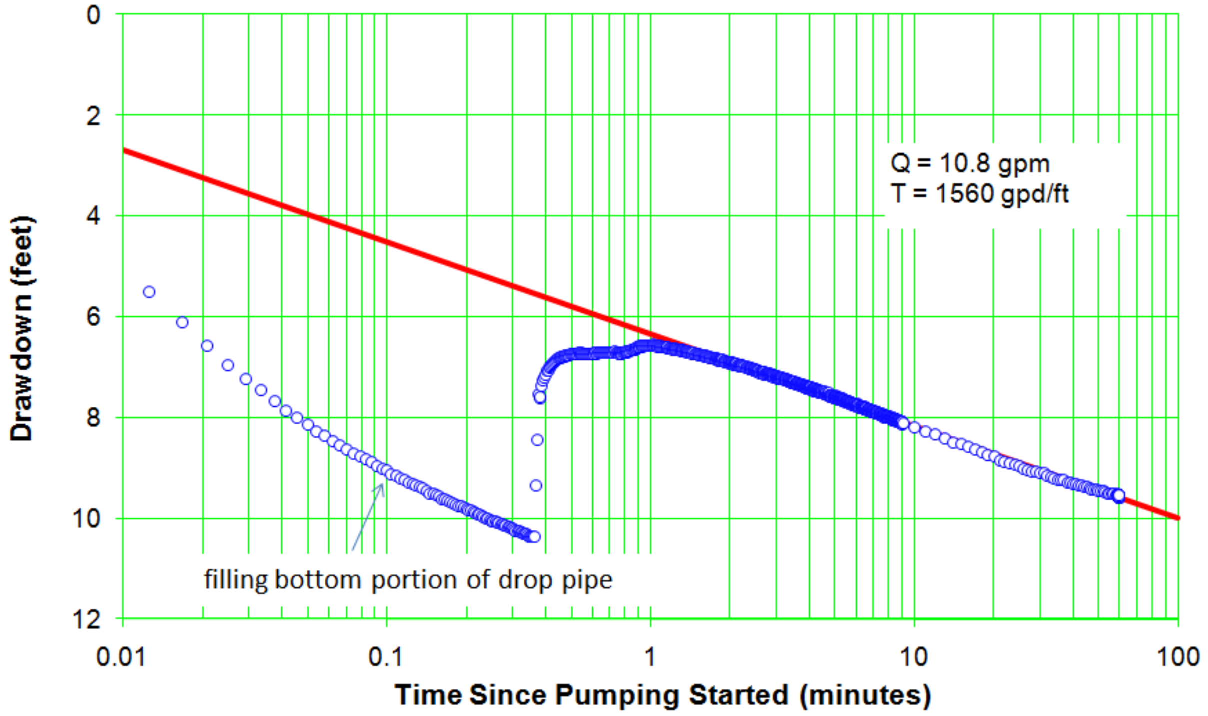


Figure E-9.2-1 Well R-52 screen 2 trial 2 drawdown

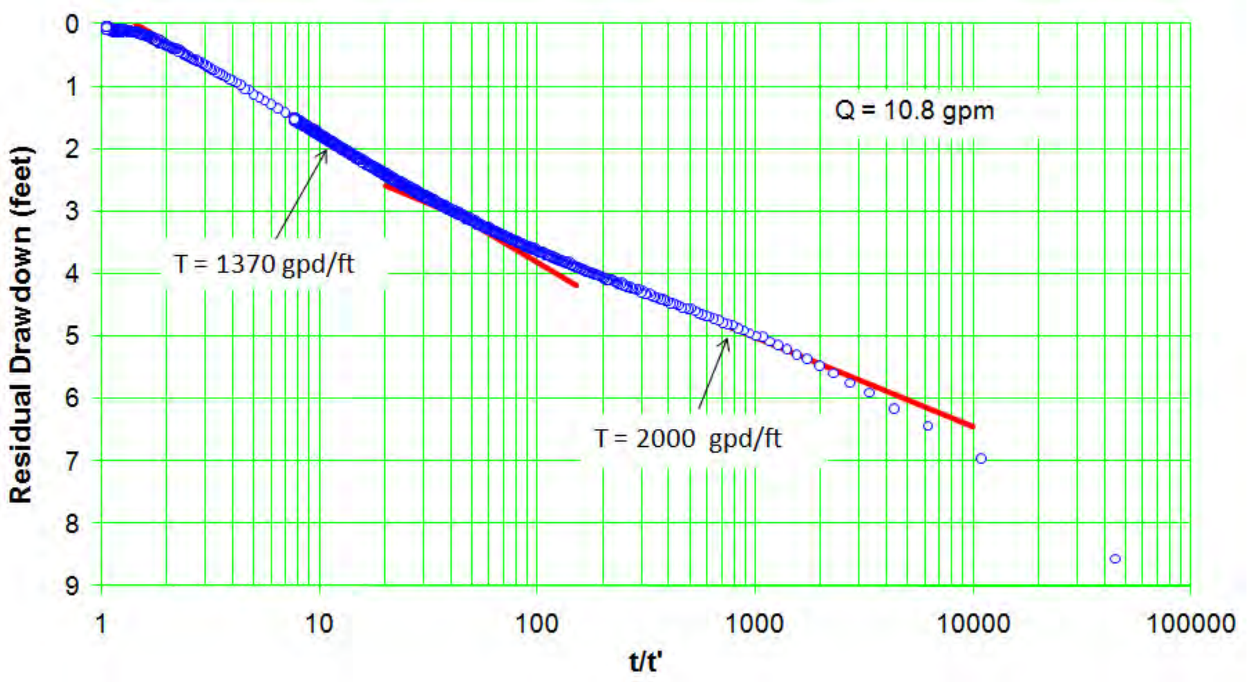


Figure E-9.2-2 Well R-52 screen 2 trial 2 recovery

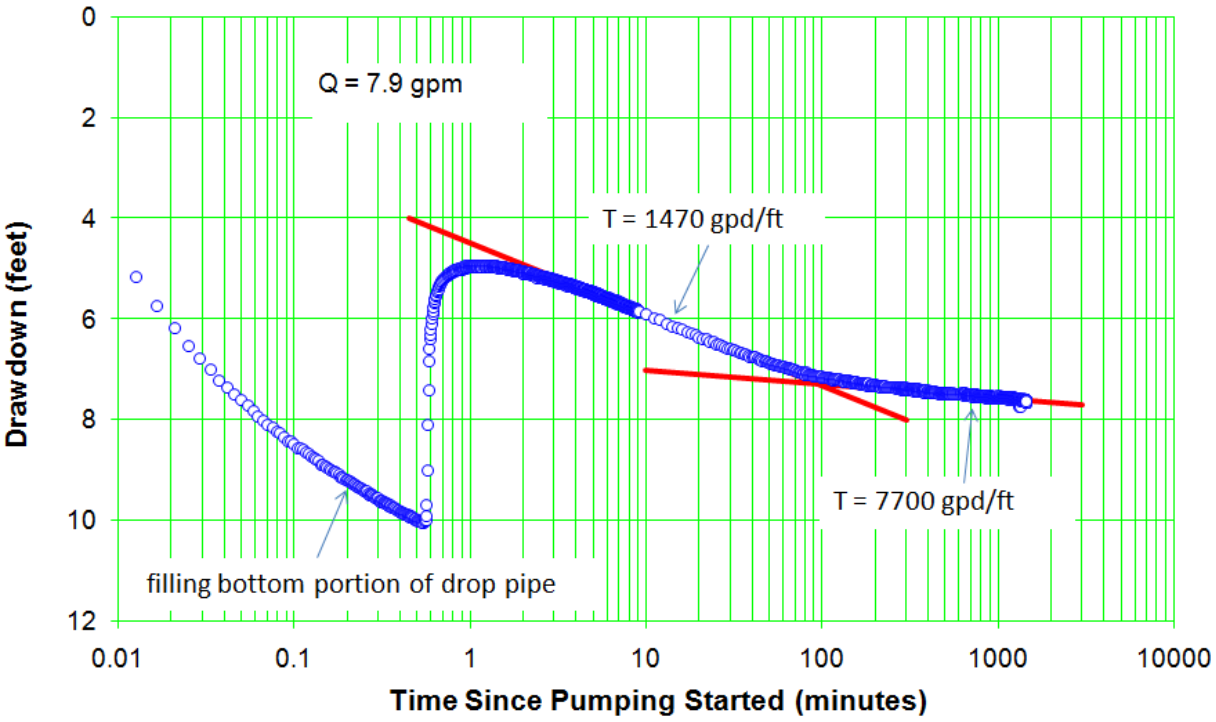


Figure E-9.3-1 Well R-52 screen 2 drawdown

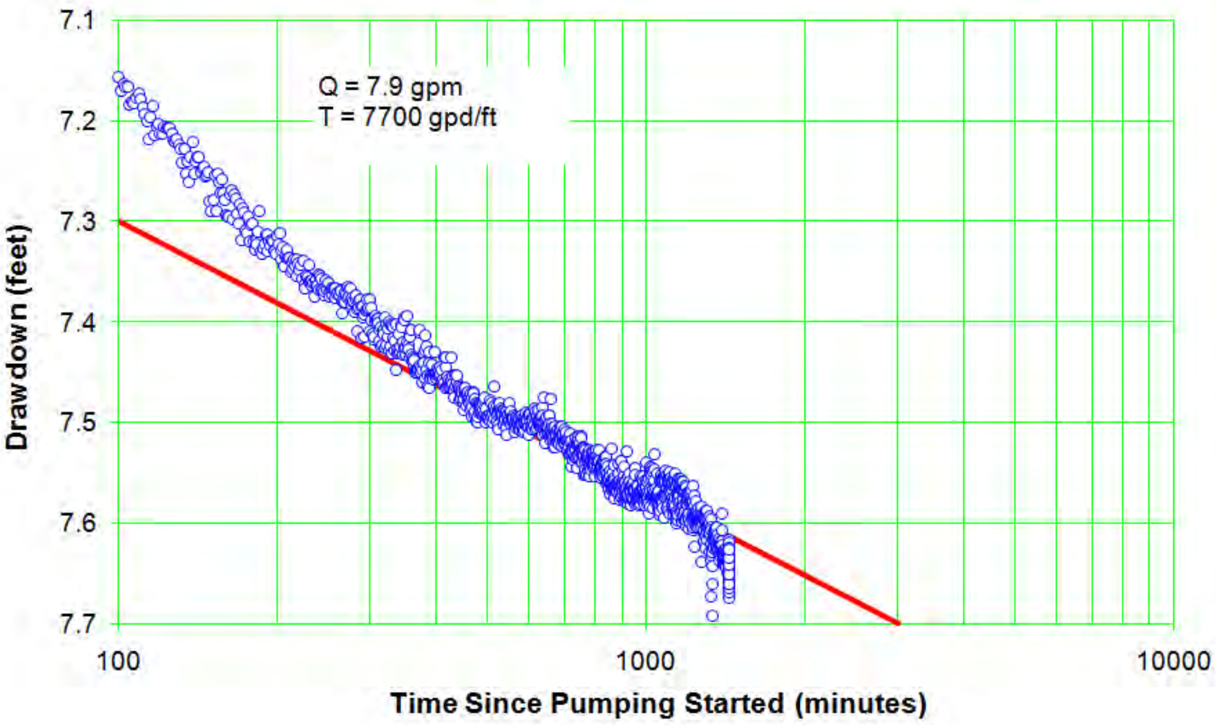


Figure E-9.3-2 Well R-52 screen 2 drawdown—expanded scale

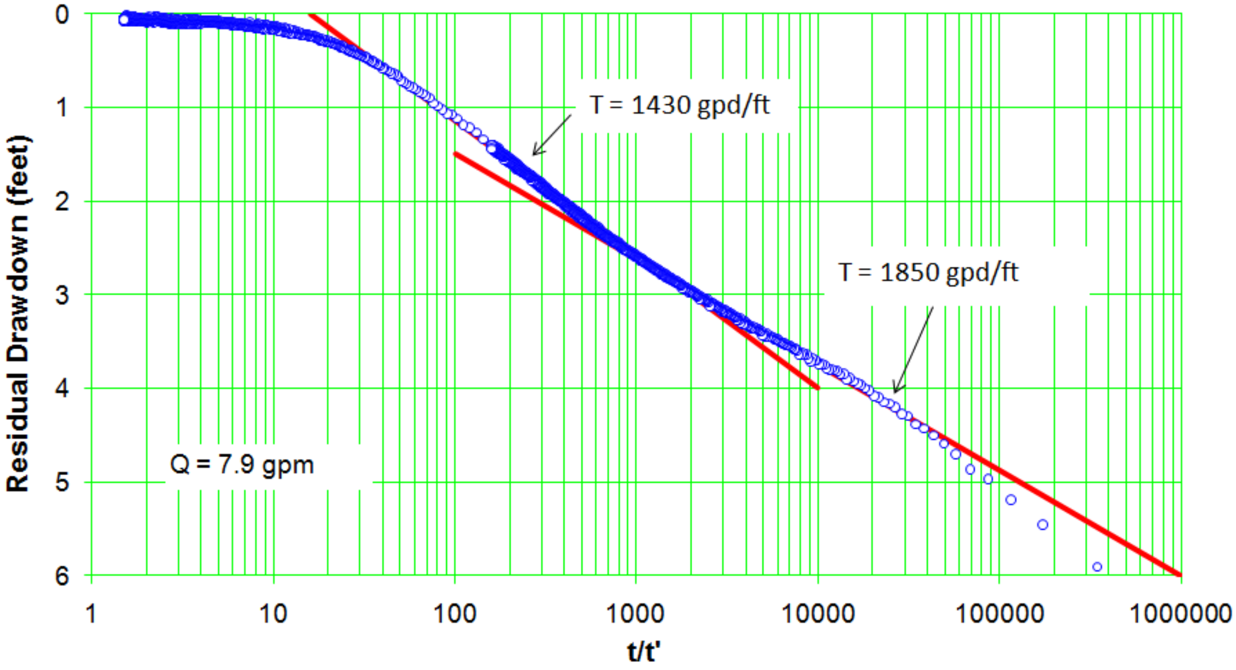


Figure E-9.3-3 **Well R-52 screen 2 recovery**

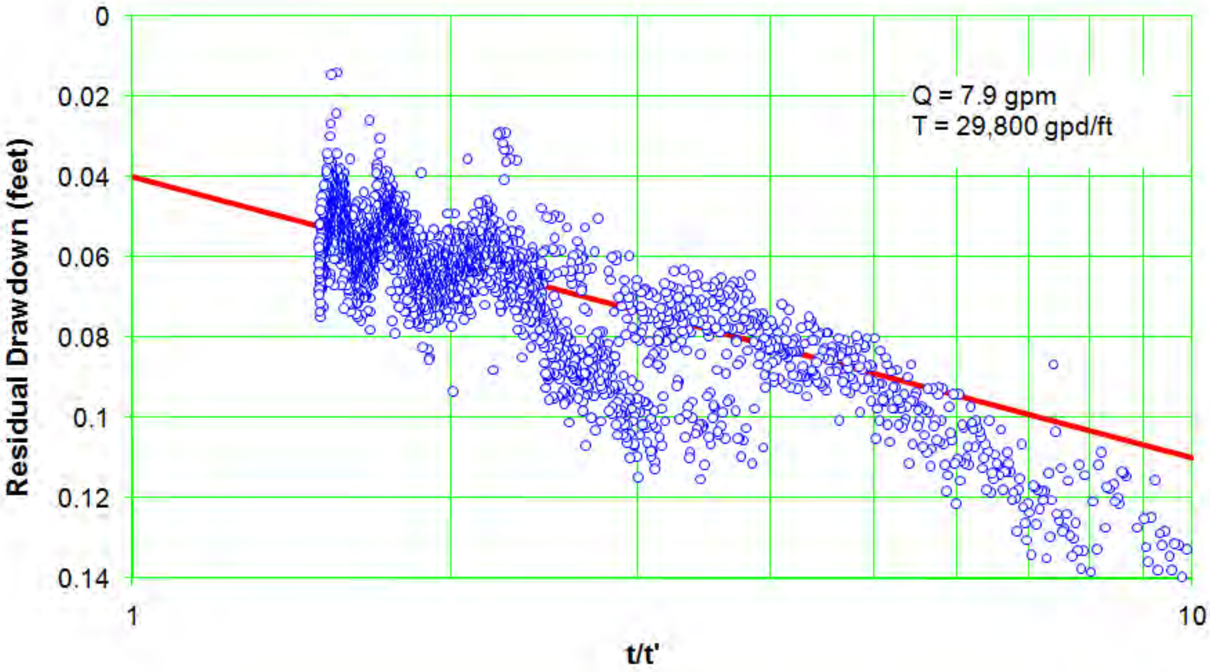


Figure E-9.3-4 **Well R-52 screen 2 recovery—expanded scale**

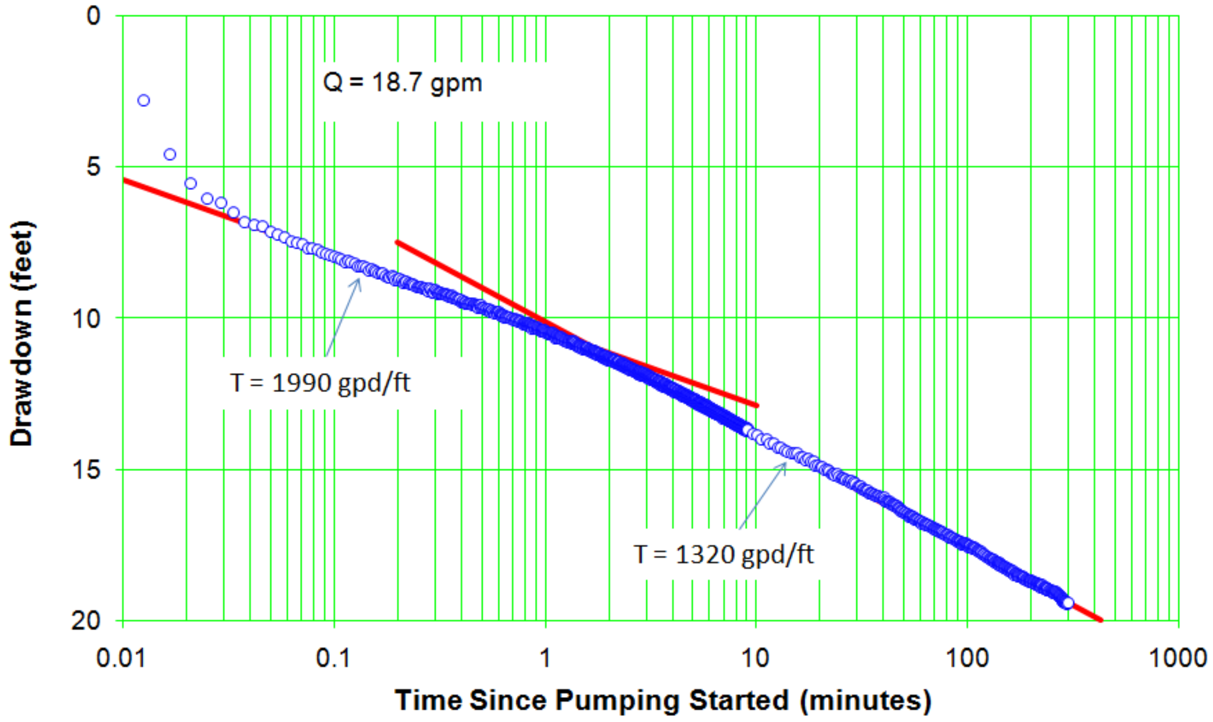


Figure E-9.4-1 Well R-52 screen 2 supplemental drawdown

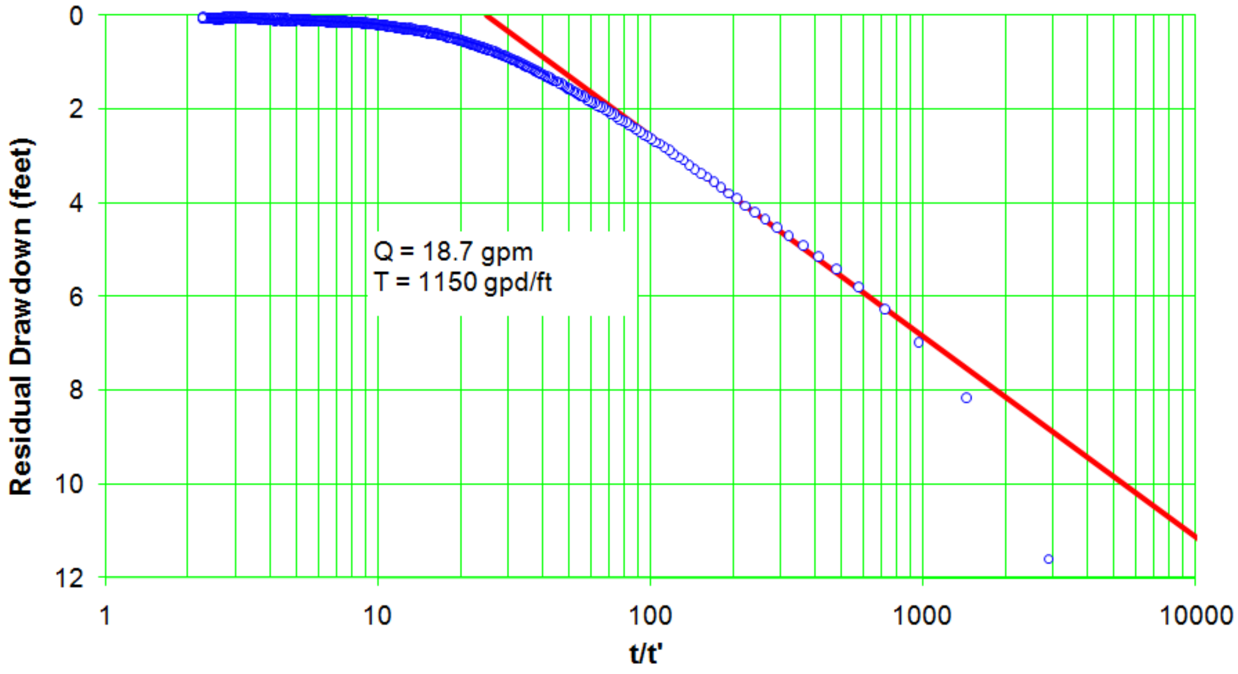


Figure E-9.4-2 Well R-52 screen 2 supplemental recovery

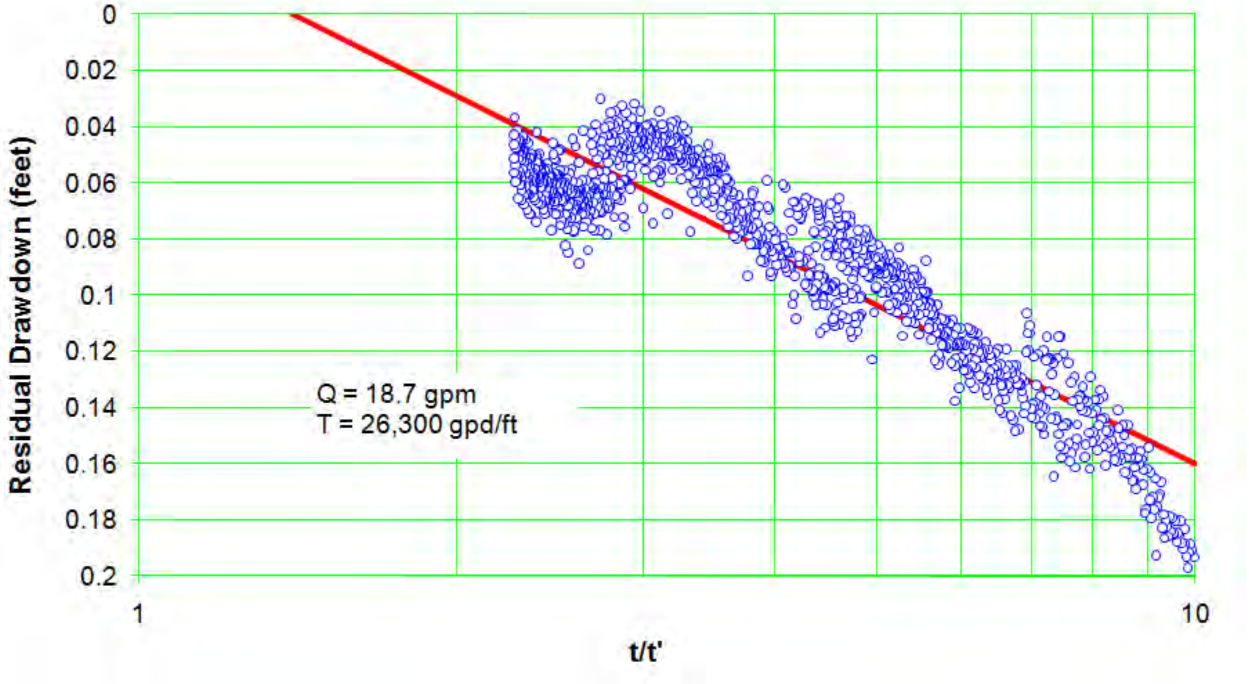


Figure E-9.4-3 Well R-52 screen 2 supplemental recovery—expanded scale

Appendix F

R-52 Proposed Final Well Design and New Mexico Environment Department Approval

F-1.0 WELL OBJECTIVES

R-52 is a regional groundwater monitoring well located on a narrow mesa between the north and south forks of Cañada del Buey (Figure F-1.0-1). Together with well R-37 and R-40, the principal objective of R-52 is to monitor groundwater quality in the regional aquifer downgradient of Material Disposal Areas (MDAs) H and J. Transport of potential contaminants is expected to occur by lateral groundwater flow within the regional aquifer.

Water-level data for R-52 will also be used in conjunction with data from nearby wells to establish vertical and lateral hydraulic gradients in the vicinity of Technical Area 54 (TA-54). The projected groundwater flow direction is towards the northeast based on water table maps. The R-52 location is closer to, and may be more directly in, the flow path from MDA H and MDA J than well R-37. Municipal water production at nearby wells PM-2 and PM-4, to the south and northwest, respectively, may affect groundwater flow directions locally, particularly in deeper parts of the regional aquifer.

The R-52 well objectives are best met by installing two well screens. The upper well screen will be placed near the regional water table to assess background water quality upgradient of MDA H and MDA J. The lower screen will be placed near the bottom of the well so that it will have sufficient separation from the upper screen to allow a Baski pump installation and be as close as possible to the tops of the well screens at PM-2 and PM-4 (Figure F-1.0-2).

F-2.0 RECOMMENDED WELL DESIGN

It is recommended that R-52 be installed as a two-screen well with an upper 20-ft stainless-steel, 20-slot, wire-wrapped well screen extending from 1035 to 1055 ft below ground surface (bgs) and a lower 10-ft stainless-steel, 20-slot, wire-wrapped well screen extending from 1107 ft to 1117 ft bgs. The depth to top of regional saturation is about 1020.6 ft (see discussion below). The primary filter packs for each 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 each primary filter pack. The proposed well design is shown in Figure F-1.0-2.

The original design for R-52 called for deeper placement of the lower screen, at 1130 to 1150 ft bgs, to place the lower screen closer to the depths of the tops of well screens at PM-2 and PM-4. However, difficulty in cutting and removing the 12-in. drill casing from a cut at 1161.5-ft depth required a higher cut (1127-ft depth) before the drill casing could be removed. Although this requires placement of the lower screen higher in the Puye Formation, the Puye sediments at the new location for the lower screen are very similar to those of the prior design and should provide comparable productivity.

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

F-3.0 WELL DESIGN CONSIDERATIONS

Preliminary lithological logs indicate that the geologic contacts are, in descending stratigraphic order: Bandelier Tuff (0–540 ft); basaltic lavas of the Cerros del Rio field and associated scoria, cinder, and sedimentary deposits (540–912 ft); and the Puye Formation (912–1174.4 ft total depth [TD]).

Potential perched intermediate groundwater was encountered at a depth of 920 ft in sediments below the Cerros del Rio basalt. A reliable water level for this zone could not be determined because large amounts of water were used to drill through this zone. A water sample was airlifted from this zone and analyses are pending. Beds with expanding clays from 965 to 980 ft provided a seal as the casing was advanced to the regional aquifer. The hydrogeologic setting of the potential perched zone is similar to one that is monitored by screen 1 at nearby well R-37.

Regional groundwater was predicted to occur at a depth of approximately 1021 ft based on water table maps for the area. A stable water level of 1016 ft bgs was measured in coarse-grained volcanic sands and gravels of the Puye Formation when the borehole was 1054 ft deep. The static water level was tagged at 1020.6 ft after reaching the TD of 1174.5 ft and removing the drilling tools from the borehole. This deeper water level is consistent with the water table map and is the value used in the proposed well design.

The Puye Formation is a coarse volcanogenic deposit that is likely derived from local Cerros del Rio volcanic sources, and to a lesser extent, from more distal Tschicoma sources. Examination of cuttings for the Puye Formation indicates a transition from deposits of silts, fine sands, and clays with minor gravels to generally fines-poor sands and gravels at a depth of approximately 980 ft. The clay- and silt-rich gravels with poor hydraulic properties occur above the water table (1020.6 ft), and they do not affect the well design. Puye deposits below the water table are uniformly coarse grained and are generally expected to have similar hydraulic properties. These deposits consist primarily of coarse lithic sands and subrounded to angular intermediate-volcanic gravels. It is likely that portions of these deposits contain cobbles and boulders, but larger clasts would have been pulverized during drilling.

Screen 1 is placed from 1035 to 1055 ft in coarse sands and gravels of the Puye Formation. The top of the well screen is placed 14 ft below the water level to ensure the well screen remains submerged during pumping development and aquifer testing.

Screen 2 targets a sequence of Puye deposits from 1107 to 1117 ft. These deposits are coarse grained throughout, and the cuttings are free of silts and fine sands.

F-4.0 OTHER DESIGN CONSIDERATIONS

Screen 1 is placed as high as possible within the regional groundwater system, consistent with the goal of remaining submerged during pumping operations. Borehole cuttings indicate that deeper horizons in the Puye fanglomerate are similar in lithology to the selected well screen interval, but offer no advantages in terms of the hydraulic characteristics.

The lower screen in the revised R-52 design is placed as deep as possible, given the cut in the drill casing at 1127-ft depth. Because of its proximity to PM-2 and PM-4, the R-52 location still provides an opportunity to observe how municipal water production near TA-54 affects water levels at different depths in the aquifer. These observations can be used to evaluate the conceptual model that pumping effects from municipal wells have a limited affect near the water table because of the highly stratified nature of the aquifer.

Screen 1 is proposed to be 20 ft long to ensure that the well screen includes a number of productive gravel beds in stratified Puye deposits and to allow for drawdown of the regional aquifer over the lifetime of the well. Screen 2 is proposed to be 10 ft long to allow sufficient spacing between screens for a Baski pump system, while keeping the lower screen above the bentonite fill that will isolate the drill-casing cutoff at 127-ft depth.

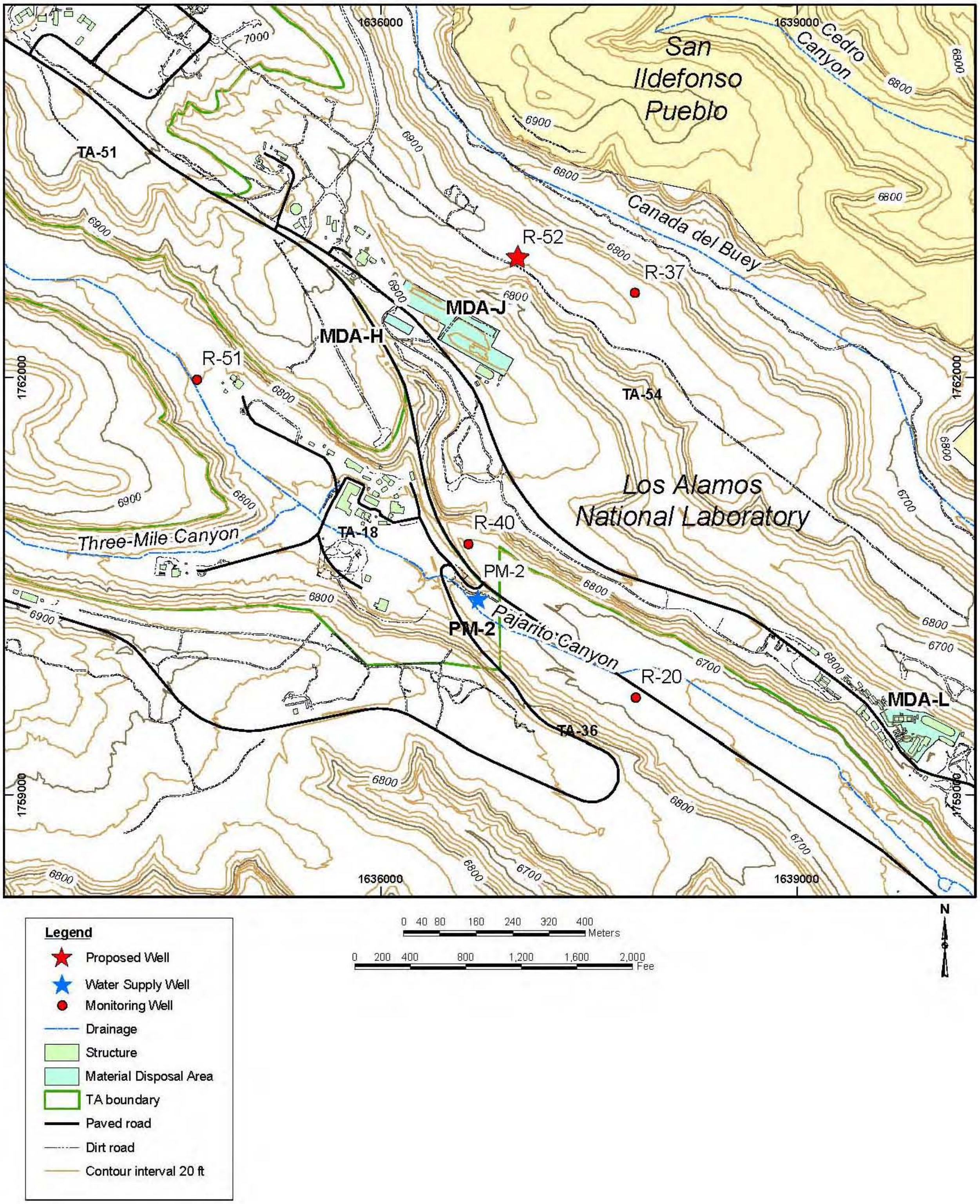


Figure F-1.0-1 Location of R-52 with nearby monitoring wells

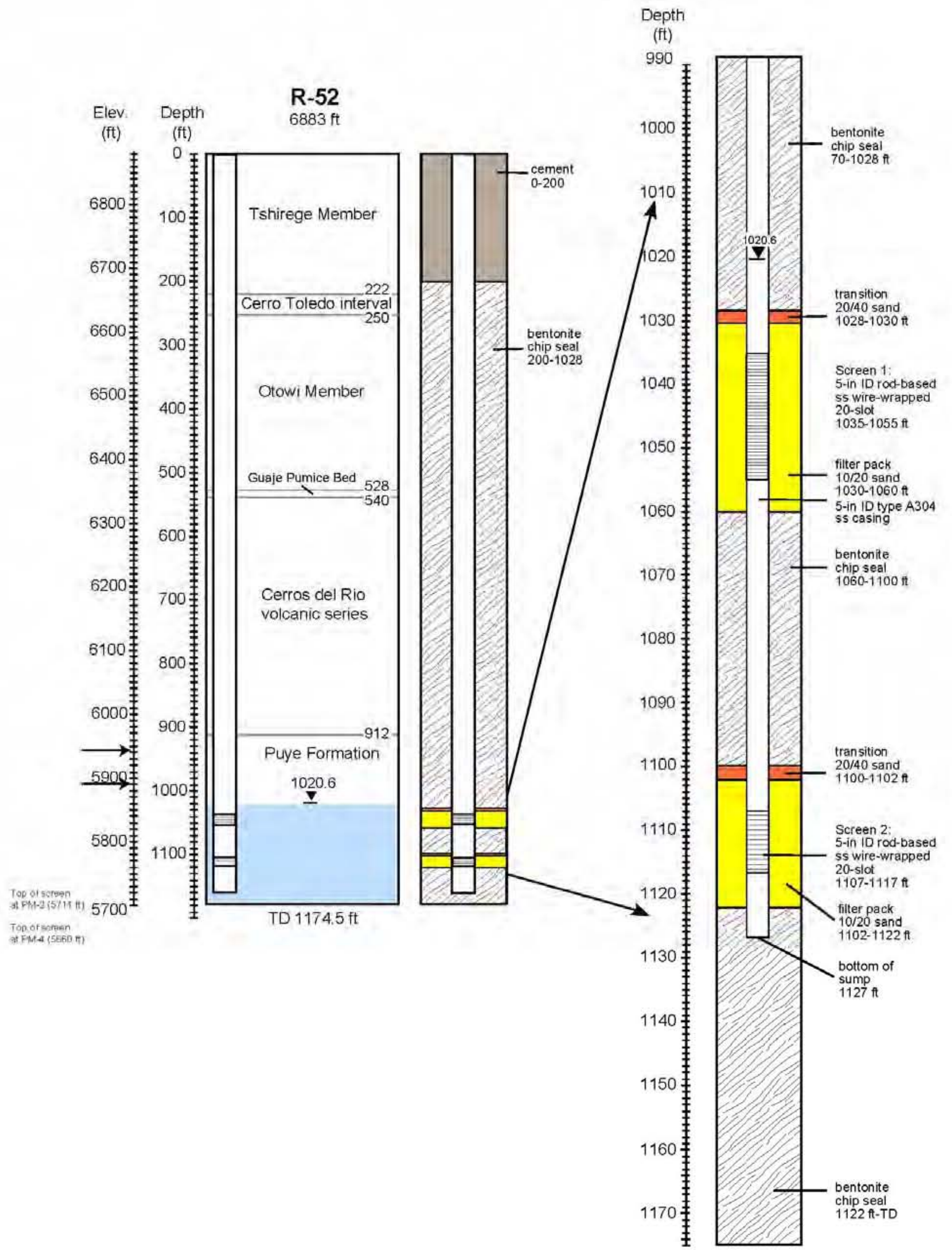
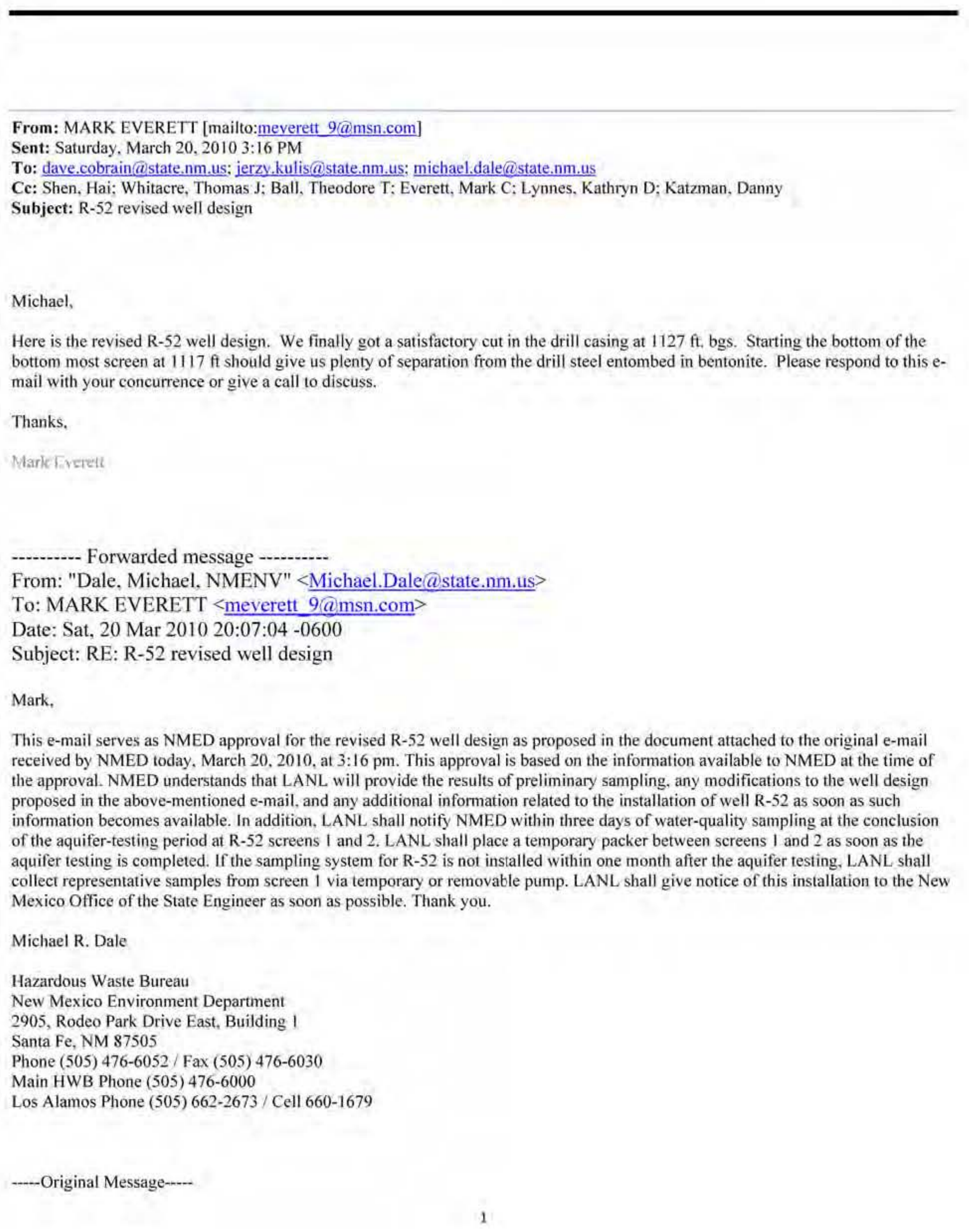


Figure F-1.0-2 Proposed well design for R-52 following cut of 12-in. drill casing at 1127-ft depth



From: MARK EVERETT [mailto:meverett_9@msn.com]
Sent: Saturday, March 20, 2010 3:16 PM
To: dave.cobrain@state.nm.us; jerzy.kulis@state.nm.us; michael.dale@state.nm.us
Cc: Shen, Hai; Whitacre, Thomas J; Ball, Theodore T; Everett, Mark C; Lynnes, Kathryn D; Katzman, Danny
Subject: R-52 revised well design

Michael,

Here is the revised R-52 well design. We finally got a satisfactory cut in the drill casing at 1127 ft. bgs. Starting the bottom of the bottom most screen at 1117 ft should give us plenty of separation from the drill steel entombed in bentonite. Please respond to this e-mail with your concurrence or give a call to discuss.

Thanks,

Mark Everett

---------- Forwarded message ----------
From: "Dale, Michael, NMENV" <Michael.Dale@state.nm.us>
To: MARK EVERETT <meverett_9@msn.com>
Date: Sat, 20 Mar 2010 20:07:04 -0600
Subject: RE: R-52 revised well design

Mark,

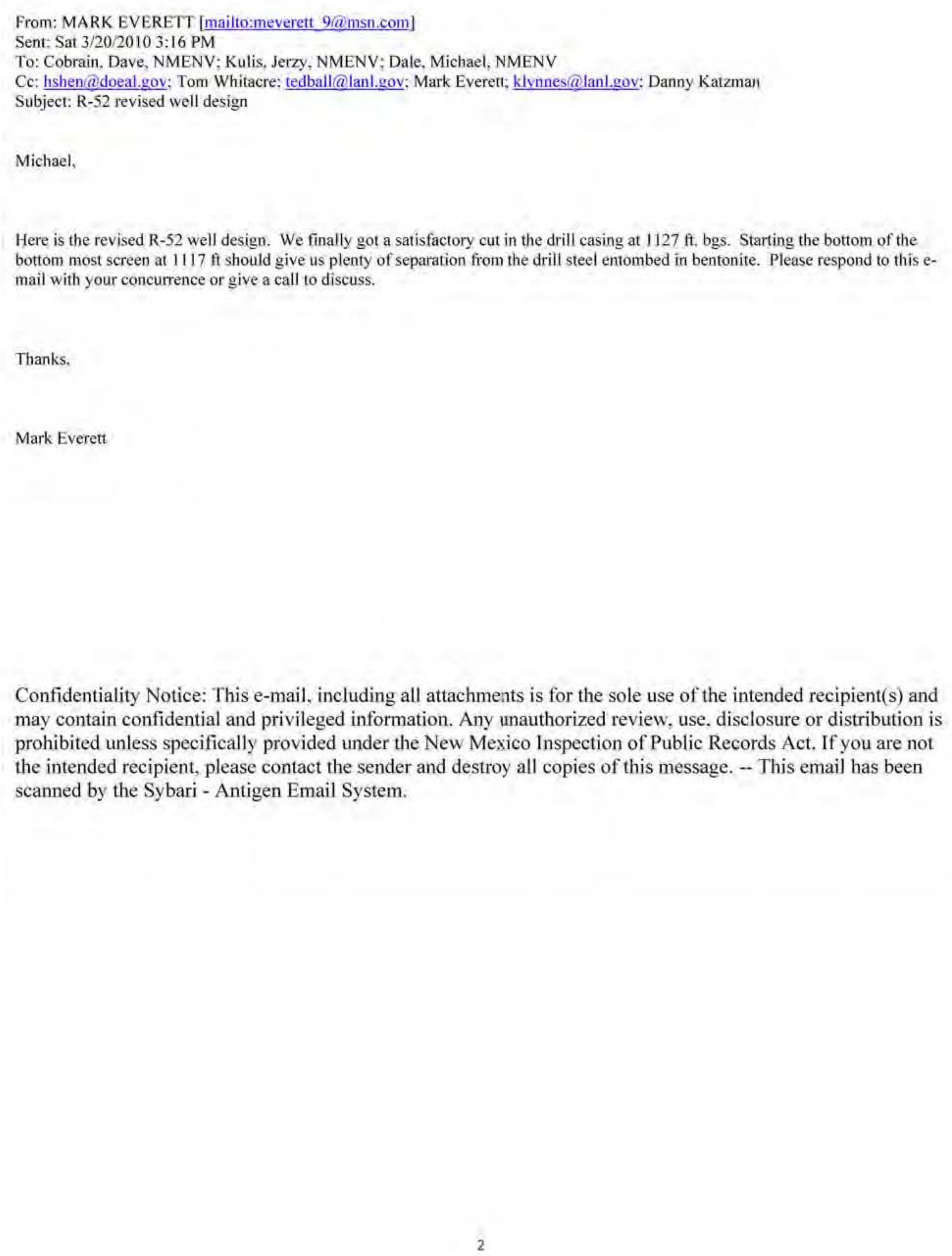
This e-mail serves as NMED approval for the revised R-52 well design as proposed in the document attached to the original e-mail received by NMED today, March 20, 2010, at 3:16 pm. This approval is based on the information available to NMED at the time of the approval. NMED understands that LANL will provide the results of preliminary sampling, any modifications to the well design proposed in the above-mentioned e-mail, and any additional information related to the installation of well R-52 as soon as such information becomes available. In addition, LANL shall notify NMED within three days of water-quality sampling at the conclusion of the aquifer-testing period at R-52 screens 1 and 2. LANL shall place a temporary packer between screens 1 and 2 as soon as the aquifer testing is completed. If the sampling system for R-52 is not installed within one month after the aquifer testing, LANL shall collect representative samples from screen 1 via temporary or removable pump. LANL shall give notice of this installation to the New Mexico Office of the State Engineer as soon as possible. Thank you.

Michael R. Dale

Hazardous Waste Bureau
New Mexico Environment Department
2905, Rodeo Park Drive East, Building 1
Santa Fe, NM 87505
Phone (505) 476-6052 / Fax (505) 476-6030
Main HWB Phone (505) 476-6000
Los Alamos Phone (505) 662-2673 / Cell 660-1679

-----Original Message-----

1



From: MARK EVERETT [mailto:meverett_9@msn.com]
Sent: Sat 3/20/2010 3:16 PM
To: Cobrain, Dave, NMENV; Kulis, Jerzy, NMENV; Dale, Michael, NMENV
Cc: hshen@doeal.gov; Tom Whitacre; tedball@lanl.gov; Mark Everett; klynnes@lanl.gov; Danny Katzman
Subject: R-52 revised well design

Michael,

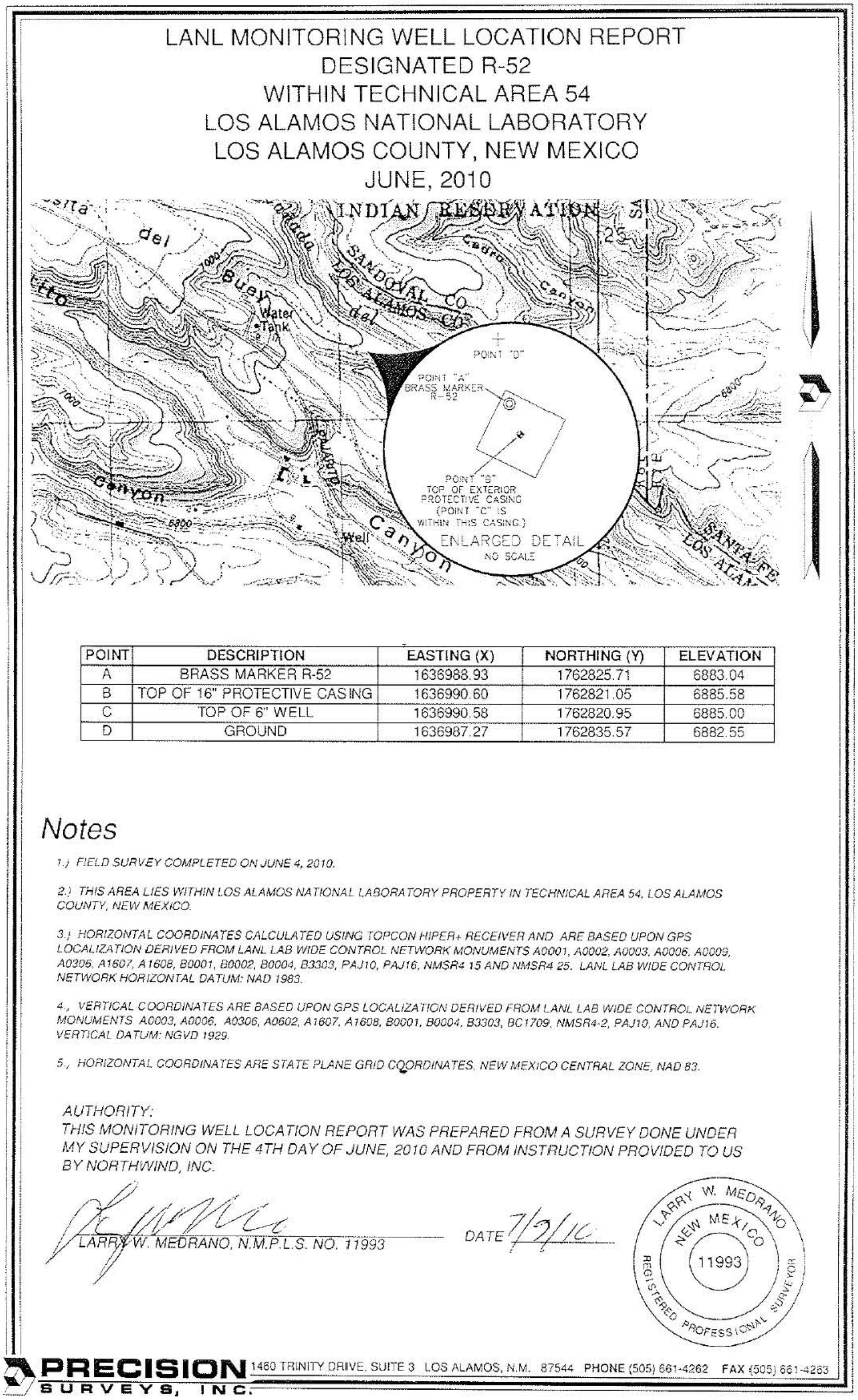
Here is the revised R-52 well design. We finally got a satisfactory cut in the drill casing at 1127 ft. bgs. Starting the bottom of the bottom most screen at 1117 ft should give us plenty of separation from the drill steel entombed in bentonite. Please respond to this e-mail with your concurrence or give a call to discuss.

Thanks,

Mark Everett

Appendix G

Survey Location Report



LANL MONITORING WELL LOCATION REPORT
DESIGNATED R-52
WITHIN TECHNICAL AREA 54
LOS ALAMOS NATIONAL LABORATORY
LOS ALAMOS COUNTY, NEW MEXICO
JUNE, 2010

POINT	DESCRIPTION	EASTING (X)	NORTHING (Y)	ELEVATION
A	BRASS MARKER R-52	1636988.93	1762825.71	6883.04
B	TOP OF 16" PROTECTIVE CASING	1636990.60	1762821.05	6885.58
C	TOP OF 6" WELL	1636990.58	1762820.95	6885.00
D	GROUND	1636987.27	1762835.57	6882.55

Notes

1.) FIELD SURVEY COMPLETED ON JUNE 4, 2010.

2.) THIS AREA LIES WITHIN LOS ALAMOS NATIONAL LABORATORY PROPERTY IN TECHNICAL AREA 54, LOS ALAMOS COUNTY, NEW MEXICO.

3.) HORIZONTAL COORDINATES CALCULATED USING TOPCON HIPER+ RECEIVER AND ARE BASED UPON GPS LOCALIZATION DERIVED FROM LANL LAB WIDE CONTROL NETWORK MONUMENTS A0001, A0002, A0003, A0006, A0009, A0306, A1607, A1608, B0001, B0002, B0004, B3303, PAJ10, PAJ16, NMSR4 15 AND NMSR4 25. LANL LAB WIDE CONTROL NETWORK HORIZONTAL DATUM: NAD 1983.

4., VERTICAL COORDINATES ARE BASED UPON GPS LOCALIZATION DERIVED FROM LANL LAB WIDE CONTROL NETWORK MONUMENTS A0003, A0006, A0306, A0602, A1607, A1608, B0001, B0004, B3303, BC1709, NMSR4-2, PAJ10, AND PAJ16. VERTICAL DATUM: NGVD 1929.

5., HORIZONTAL COORDINATES ARE STATE PLANE GRID COORDINATES, NEW MEXICO CENTRAL ZONE, NAD 83.

AUTHORITY:
THIS MONITORING WELL LOCATION REPORT WAS PREPARED FROM A SURVEY DONE UNDER MY SUPERVISION ON THE 4TH DAY OF JUNE, 2010 AND FROM INSTRUCTION PROVIDED TO US BY NORTHWIND, INC.

LARRY W. MEDRANO, N.M.P.L.S. NO. 11993 *DATE* 7/2/10

LARRY W. MEDRANO
NEW MEXICO
11993
REGISTERED PROFESSIONAL SURVEYOR

PRECISION SURVEYS, INC. 1460 TRINITY DRIVE, SUITE 3 LOS ALAMOS, N.M. 87544 PHONE (505) 661-4262 FAX (505) 661-4263