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Completion Report for Regional Aquifer Well R-29

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EXECUTIVE SUMMARY

This well completion report describes the drilling, installation, development, and aquifer testing of regional groundwater monitoring well R-29, located north of Ancho Canyon, within Los Alamos National Laboratory Technical Area 49 (TA-49). This report was written in accordance with the requirements in Section IV.A.3.e.iv of the Compliance Order on Consent.

Well R-29 was installed at the direction of the New Mexico Environment Department (NMED) to provide a regional aquifer monitoring well downgradient of TA-49, establish water levels in the regional aquifer in this area, determine whether zones of perched-intermediate groundwater occur under Material Disposal Area AB, and resolve uncertainty about whether the lavas described during installation of earlier deep test wells are Tschicoma dacite or Cerros del Rio volcanic rocks.

The R-29 borehole was successfully completed to a total depth of 1248.0 ft below ground surface (bgs) using dual-rotary, fluid-assisted, and standard air-rotary drilling methods. Fluid additives used included potable water and foam. No drilling fluids, other than air and small amounts of potable water, were used below 1047.0 ft bgs, roughly 100 ft above the regional aquifer.

Geologic units penetrated included the Tshirege Member of the Bandelier Tuff, the Cerro Toledo interval, the Otowi Member of the Bandelier Tuff, the Guaje Pumice Bed, and the Puye Formation. Neither Tschicoma dacite nor Cerros del Rio volcanic rocks were encountered at R-29. No perched groundwater was detected during drilling.

The R-29 monitoring well was completed with a 10.0-ft-long single screen from 1170.0 to 1180.0 ft bgs to evaluate water quality and measure water levels in the regional aquifer within the Puye Formation. The water level after well completion was measured at 1152.5 ft bgs. The well was completed in accordance with the NMED-approved well design. Well development and aquifer testing activities indicate the well will perform effectively to meet the planned objectives. A dedicated sampling system and water-level transducer were installed, and groundwater sampling will be performed as part of the facility-wide groundwater-monitoring program.

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Acronyms and Abbreviations

amsl	above mean sea level
APS	Accelerator Porosity Sonde
ASTM	American Society for Testing and Materials
bgs	below ground surface
Consent Order	Compliance Order on Consent
DO	dissolved oxygen
ECS	Elemental Capture Spectroscopy
EES-14	Earth and Environmental Sciences Group 14
Eh	oxidation-reduction potential
EP	Environmental Programs
EPA	Environmental Protection Agency (U.S.)
gpd	gallons per day
gpm	gallons per minute
HE	high explosives
HNGS	Hostile Natural Gamma Spectroscopy
hp	horsepower

ICPMS	inductively coupled plasma mass spectrometry
ICPOES	Inductively coupled plasma optical emission spectroscopy
I.D.	inside diameter
LANL	Los Alamos National Laboratory
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
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 1g	Unit 1g of Tshirege Member of the Bandelier Tuff
Qbt 1v	Unit 1v of Tshirege Member of the Bandelier Tuff
Qbt 2	Unit 2 of Tshirege Member of the Bandelier Tuff
Qbt 3	Unit 3 of Tshirege Member of the Bandelier Tuff
Qbt 4	Unit 4 of Tshirege Member of the Bandelier Tuff
Qct	Cerro Toledo interval
RCRA	Resource Conservation and Recovery Act
RPF	Records Processing Facility
SOP	standard operating procedure
SU	standard unit
TA	technical area
TD	total depth
TDL	Triple Detector Lithodensity
TOC	total organic carbon
Tpf	Puye Formation
VOC	volatile organic compound
WES-EDA	Environmental Services Division–Environmental Data and Analysis
WCSF	waste characterization strategy form

1.0 INTRODUCTION

This completion report summarizes site preparation, borehole drilling, well construction, well development, aquifer testing, and dedicated sampling system installation for regional groundwater monitoring well R-29. 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-29 monitoring well borehole was drilled and installed from February 12 to March 12, 2010, at Los Alamos National Laboratory (LANL or the Laboratory) for the Environmental Programs (EP) Directorate.

The R-29 project site is located north of Ancho Canyon, within the Laboratory's Technical Area 49 (TA-49) (Figure 1.0-1). Well R-29 was drilled at the direction of NMED to provide a regional aquifer monitoring well downgradient of TA-49 and to help define the nature and extent of contamination in the area. Other objectives were to establish the water level in the regional aquifer in this area, determine whether zones of perched-intermediate groundwater occur under Material Disposal Area AB, and resolve uncertainty about whether the lavas described during installation of earlier deep test wells are Tschicoma dacite or Cerros del Rio volcanic rocks.

The R-29 borehole was drilled to a total depth (TD) of 1248.0 ft below ground surface (bgs). A monitoring well was then installed with one 10-ft screen between 1170.0 and 1180.0 ft bgs. The depth to water before well installation was measured at 1151.5 ft bgs on February 27, 2010, and 1152.5 ft bgs after well installation before aquifer testing on March 21, 2010. During drilling, cuttings samples were collected at 5-ft intervals in the borehole from ground surface to TD.

Postinstallation activities included well development, aquifer testing, surface completion, geodetic surveying, and dedicated sampling system installation. 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 completed to date associated with the R-29 project.

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 and procedures and regulatory requirements.

2.1 Administrative Preparation

The following documents helped guide the implementation of the scope of work for well R-29:

- "Well R-29 Drill Plan—Final, Installation of Well R-29, TA-49, Los Alamos National Laboratory, Revision 1" (North Wind Inc. 2010, 109456)
- "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 South Canyon Wells R-29 and R-30 (TA-49, MDA-AB) Regional Groundwater Well Installation and Corehole Drilling" (LANL 2009, 107444)

2.2 Site Preparation

The drill pad was constructed by Laboratory personnel before the rig was mobilized. Between February 8 and 10, 2010, activities included moving the dual-rotary drill rig, air compressors, trailers, and support vehicles to the drill site and staging alternative drilling tools and construction materials at the Pajarito Road laydown yard.

3.0 DRILLING ACTIVITIES

This section describes the drilling strategy and approach and provides a chronological summary of field activities conducted at well R-29.

3.1 Drilling Approach

The R-29 borehole was drilled using a Schramm Inc. 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. Other drilling equipment included tricone bits, downhole hammer bits, and 5.5-in. dual-wall drill pipe. Auxiliary equipment included three Ingersoll Rand 1070 ft^3/min trailer-mounted air compressors and two Sullair 1150 ft^3/min trailer-mounted air compressors. Casing sizes used included 24-in., 18-in., and 12-in. The dual-rotary technique 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 5.563-in.-outside diameter (O.D.) well, as required by the Consent Order (Section X.C.3), would be met.

Drilling additives were used as needed, along with potable water and air, between ground surface and 1047.0 ft bgs (approximately 100 ft above the anticipated top of the regional aquifer). The fluids and additives were used to cool the bit and help lift cuttings from the borehole. Only potable water and air were used below 1047.0 ft bgs. Potable water was also used during borehole jetting and cleaning activities before the regional well was constructed. Total amounts of drilling fluids and additives introduced into the borehole and those recovered are presented in Table 3.1-1.

3.2 Chronological Drilling Activities

The necessary drilling equipment and supplies were mobilized to the R-29 site between February 8 and 10, 2010. Notice to proceed was received from the Laboratory on February 10. Decontamination of tools and equipment continued through February 11, and drilling began on February 12 at 0800.

Between February 12 and 14, a 24-in. steel casing was advanced using dual-rotary techniques and a 24-in. tricone bit to 52.4 ft bgs. An 18-in. casing was landed at the same depth and set in a bentonite plug, and a 17.5-in. open borehole was advanced from 52.4 to 196.4 ft bgs using a 17-in. tricone bit. On February 14, drilling was temporarily halted to allow for minor repositioning of the rig over the borehole.

The borehole was advanced to 938.7 ft bgs on February 16, when drilling activities were temporarily paused to monitor for perched water. After a recovery period of approximately 35 min, water was tagged multiple times in a 2-h period, but the water-level measurements were inconsistent and fluctuated between 910.8 and 916.7 ft bgs. After a failed attempt to airlift a groundwater sample, the decision was made to continue drilling. The 17.5-in. borehole was advanced to 1060.0 ft bgs between February 14 and 16. The use of foam was discontinued at 1047.0 ft bgs.

The Laboratory video camera and natural gamma/induction tools were run in the borehole on February 17 with a borehole depth of 1060.0 ft bgs. Standing water, believed to be drilling water, was present at 972.0 ft bgs. The video camera showed no water entering along the borehole wall in the expected zone of perched saturation. It also showed large washouts from 566.0 to 580.0 ft bgs and at about 893 ft bgs. The natural gamma and induction tools tagged the borehole bottom at 1031.0 ft bgs, indicating that roughly 29.0 ft of slough was present.

Between February 18 and 24, 12-in. casing-advance drilling continued through the slough to 1195.0 ft bgs using an 11 7/8-in. hammer bit with a 14 1/4-in. under-reamer during which time regional aquifer saturation was first detected at 1175.0 ft bgs.

On February 25 at 1415 h, open-hole drilling was completed to TD of 1248.0 ft bgs using an 11 7/8-in. tricone bit. A water sample was air-lifted from this depth, as required in the drilling work plan. Discharge was estimated at 25 to 30 gallons per minute (gpm). Groundwater was tagged at 1151.5 ft bgs over a 4-h period on February 26 before the well was installed.

During drilling, 24-h operations were conducted, consisting of two 12-h shifts, 7 d/wk. Other than some sloughing of formational material during drilling, borehole instability issues were not encountered that noticeably impeded progress. Minor slowdowns occurred while the cyclone, coupling, and casing-rotator shoe were repaired, as well as during the repositioning of the drill rig.

4.0 SAMPLING ACTIVITIES

This section describes the cuttings and groundwater sampling activities for monitoring well R-29. All sampling activities were conducted in accordance with applicable quality procedures.

4.1 Cuttings Sampling

Cuttings samples were collected from the R-29 borehole at 5-ft intervals from ground surface to the TD of 1248.0 ft bgs. At each interval, approximately 500 mL of bulk cuttings were collected by the site geologist from a discharge cyclone, placed in resealable plastic bags, labeled, and archived in core boxes. Sieved fractions (>#10 and >#35 mesh) were also collected from ground surface to TD and placed in chip trays, along with unsieved (whole rock) cuttings. Recovery of the samples was good; total recovery was essentially 100% of the borehole. The only interval without recovery was from 780.0 to 785.0 ft bgs. The core boxes and chip trays were delivered to the Laboratory's archive at the conclusion of drilling activities. All screening measurements were within the range of background values.

Borehole stratigraphy at R-29 is summarized in section 5.1, and a detailed lithologic log is provided in Appendix A.

4.2 Water Sampling

Regional groundwater samples were collected from the top of the regional aquifer and at borehole TD during drilling. The sample from the upper regional aquifer was collected on February 21, 2010, by airlifting from a depth of 1175.0 ft bgs. The sample from the lower regional aquifer was collected on February 25 by airlifting from 1248 ft bgs. Samples were analyzed for metals, anions, (including perchlorate), cations, high explosive (HE) compounds, and volatile organic compounds (VOCs).

Three groundwater samples were collected during well development from the development pump's discharge line. All samples were analyzed for total organic carbon (TOC), and the final sample was also analyzed for metals and anions. Table 4.2-1 summarizes screening samples collected at R-29. Groundwater chemistry and field water-quality parameters are discussed in Appendix B.

Groundwater characterization samples will be collected from the completed well in accordance with the Consent Order. For the first year, the samples will be analyzed for the full suite of constituents, including radioactive elements; 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 at R-29 will be evaluated and presented in the annual "Interim Facility-Wide Groundwater Monitoring Plan."

5.0 GEOLOGY AND HYDROGEOLOGY

A brief description of the geologic and hydrogeologic features encountered at R-29 is presented below. The Laboratory's geology task leader and site geologists examined cuttings to determine geologic contacts and hydrogeologic conditions. Drilling observations, video logging, and water-level measurements were used to characterize groundwater occurrences.

5.1 Stratigraphy

The stratigraphy observed in the R-29 borehole is based on lithologic descriptions of cuttings samples collected from the discharge cyclone and borehole geophysical logs and described below in order of youngest to oldest geologic units. Figure 5.1-1 illustrates the stratigraphy encountered at R-29. A detailed lithologic log based on microscopic examination and analysis of drill cuttings is presented in Appendix A.

Alluvium (0–10 ft bgs)

Alluvial sediments were encountered at R-29 from ground surface to 10 ft bgs. These sediments consisted of fine to medium grained silts and sands with minor gravels, including intermediate composition volcanic lithic fragments and pumice fragments, minor quartz and sanidine crystals. Well pad construction gravel and abundant woody debris were also present in this interval.

Unit 4, Tshirege Member of the Bandelier Tuff (10–85 ft bgs)

Unit 4 of the Tshirege Member of the Bandelier Tuff occurred from 10 to 85 ft bgs. Unit 4 consisted of pale brown to light gray, weakly welded to nonwelded, and weathered ash-flow tuffs with crystal-poor pumice fragments, volcanic lithics, and quartz and sanidine phenocrysts (generally about 10% to 15% or less) in an ashy matrix. Pumices in this unit generally had a sugary appearance because of devitrification.

Unit 3, Tshirege Member of the Bandelier Tuff, Qbt 3 (85–185 ft bgs)

Unit 3 of the Tshirege Member of the Bandelier Tuff occurred from 85 to 185 ft bgs. Unit 3 consisted of moderately to nonwelded, vapor-phase altered ash-flow tuffs white to light gray in color, slightly weathered. Present were crystal-rich pumice fragments, minor volcanic lithics, and quartz and sanidine phenocrysts in an ashy matrix.

Unit 2, Tshirege Member of the Bandelier Tuff, Qbt 2 (185–275 ft bgs)

Unit 2 of the Tshirege Member of the Bandelier Tuff occurred from 185 to 275 ft bgs. Unit 2 consisted of light gray to gray and light brownish-gray, moderately to strongly welded, crystal-rich, devitrified ash-flow tuffs with porous pumices altered by vapor-phase crystallization. The tuffs included some volcanic lithics and abundant quartz and sanidine phenocrysts. Minor orange-brown iron-oxide staining was apparent on pumice and lithic fragments.

Unit 1v, Tshirege Member of the Bandelier Tuff, Qbt 1v (275-375 ft bgs)

Unit 1v of the Tshirege Member of the Bandelier Tuff occurred from 275 to 375 ft bgs. Unit 1v consisted of light gray, weakly to nonwelded, devitrified, crystal rich ash-flow tuffs. The tuffs contained white to light gray pumices that exhibited a more fibrous/porous structure downsection. The tuffs included some volcanic lithics and abundant quartz and sanidine phenocrysts. Some orange to orange-brown oxidation was apparent on pumice fragments.

Unit 1g, Tshirege Member of the Bandelier Tuff, Qbt 1g (375–550 ft bgs)

Unit 1g of the Tshirege Member of the Bandelier Tuff occurred from 375 to 550 ft bgs. Unit 1g consisted of white to light gray, nonwelded, vitric ash-flow tuffs. The tuffs included glassy pumices that exhibited a strong fibrous/porous structure, minor volcanic lithics, and abundant quartz and sanidine phenocrysts.

Cerro Toledo Interval, Qct (550–653 ft bgs)

Tephra and volcaniclastic rocks of the Cerro Toledo interval occurred from 550 to 653 ft bgs. This interval consisted of very pale brown to gray-light gray tuffaceous sedimentary deposits. These deposits consisted predominantly of moderately sorted fine to coarse sand and gravel (largely intermediate composition volcanic lithics, likely derived from Tschicoma dacites in the Jemez Mountains), reworked tuff/pumice fragments, and quartz and sanidine crystals. Orange-brown oxidation was apparent on most clasts.

Otowi Member of the Bandelier Tuff, Qbo (653–893 ft bgs)

The Otowi Member of the Bandelier Tuff occurred from 653 to 893 ft bgs. The Otowi Member consisted of white to light gray, gray and pinkish-gray, weakly to nonwelded, vitric, pumiceous ash-flow tuffs. The tuffs contained light gray to orange-brown fibrous/porous, glassy pumice, varieties of intermediate volcanic lithics and abundant quartz and sanidine phenocrysts. Also present were trace to minor amounts of red oxidized lithic fragments.

Guaje Pumice Bed of the Otowi Member of the Bandelier Tuff, Qbog (893–904 ft bgs)

The Guaje Pumice Bed occurred from 893 to 904 ft bgs. The contacts for this unit are readily apparent in geophysical logs, video logs and in the cuttings. Cuttings contain light gray to orange-brown, fibrous, vitric pumice fragments, volcanic lithics, and crystals. The #10 sieved fraction contained about 20% to 35% pumice fragments.

Puye Formation, Tpf (904–1248 ft bgs)

Puye Formation occurred from 904 to 1248 ft bgs and consisted of predominantly fluvial sedimentary deposits. These deposits included volcaniclastic sediments light gray to reddish-gray in color. Cuttings for this unit consist of poorly to well-sorted sand and subangular to subrounded gravel and minor silt. Sand and gravel consisted of up to 100% felsic-intermediate composition volcanic lithics (including dacite), pumice fragments, tuffaceous sandstone and siltstone, and crystals. Fresh angular gravel with remnants of rounded surfaces suggest the borehole penetrated significant deposits of cobbles and boulders that were milled or pulverized during drilling. Massive deposits of cobbles and boulders were observed in the Puye Formation in a video log made before the borehole reached the regional aquifer.

5.2 Groundwater

Perched groundwater was not detected in R-29 during drilling. Although perched water was anticipated at around 918 ft bgs at the base of the Guaje Pumice Bed, perched water was not observed at this interval on the video log from February 17, 2010. An additional zone of perched water anticipated around 1088.0 ft bgs at the top of the Cerros del Rio volcanic rocks or Tschicoma dacite was also absent. Neither unit was present at R-29 based on an analysis of drill cuttings.

On February 21, regional groundwater was first detected in the Puye Formation during drilling at approximately 1175.0 ft bgs. On February 26 and 27, after the TD of 1248.0 ft bgs had been reached, but before well installation began, the depth to regional groundwater was tagged five times over a 4-h period at 1151.5 ft bgs.

6.0 BOREHOLE LOGGING

The following sections describe the video and geophysical logging conducted at R-29. A summary of all logging is provided in Table 6.0-1.

6.1 Video Logging

Laboratory personnel ran video logs at R-29 on February 17 in the open borehole to 972 ft bgs to verify perched water occurrences and on February 28 to 1248 ft bgs (TD) in the cased borehole to verify cut-off of 12-in. casing. Details of these logs are provided in Table 6.0-1. Video logs are provided on DVDs as Appendix D with this report.

6.2 Geophysical Logging

Laboratory personnel ran natural gamma and array induction logs in the R-29 borehole on February 17, 2010. Additionally, a suite of Schlumberger geophysical logs was run inside the temporary 12-in.-inside diameter (I.D.) casing from ground surface to the TD of 1248 ft bgs on February 27, 2010. These geophysical logs included Accelerator Porosity Sonde (APS), Triple Detector Lithodensity (TDL), Elemental Capture Spectroscopy (ECS), Hostile Natural Gamma Spectroscopy (HNGS) and gamma ray logs. Interpretation and details of the logging are presented in the geophysical logging report and accompanying CD included in Appendix E.

7.0 WELL INSTALLATION

The R-29 well was installed between February 28 and March 2, 2010. The following sections provide the well design and a summary of well-construction activities.

7.1 Well Design

The R-29 well was designed in accordance with the R-29 drilling plan. NMED approved the final well design before the well was installed. The well was designed with a single screened interval between 1170.0 ft and 1180.0 ft bgs to monitor the quality of the regional groundwater and the water level in the Puye Formation.

7.2 Well Construction

The R-29 monitoring well was constructed of 5.0-in.-I.D./5.563-in.-O.D. passivated type A304 stainless-steel threaded casing fabricated to American Society for Testing and Materials (ASTM) standard A312. The screened interval consisted of one 10-ft length of 5.0-in.-I.D. rod based, 0.020-in. slot, wire-wrapped well screen. Compatible external stainless-steel couplings (also passivated type A304 stainless-steel fabricated to ASTM A312 standards) were used to join all individual casing and screen section. Casing and the screen were provided by the Laboratory and were steam-pressure washed on-site before they were installed. A 2.5-in.-O.D. steel flush-threaded tremie pipe string, also decontaminated before use, was used to deliver annular fill materials downhole during well construction.

The top of the 10-ft-long screen was set at 1170.0 ft bgs. An 11.8-ft stainless-steel sump was placed below the bottom of the screen. Stainless-steel centralizers (two sets of four) were welded to the well casing approximately 2 ft above and below the well screen. Figure 7.2-1 presents an as-built schematic showing construction details for the completed well.

Decontamination of the stainless-steel well casing, screens, and tremie pipe along with mobilization of initial well-construction materials to the site took place from February 24 to 27, while the borehole water level was being monitored and preparation for geophysical logging was underway.

On February 28 at 0016 h, the first joint of 5-in. stainless-steel well casing was tripped into the borehole. Each casing section was threaded to the string using stainless-steel couplings. The well casing was set that afternoon, with the bottom of the well tagged at 1191.8 ft bgs. Slough was tagged at 1247.3 ft bgs. A water line and materials pump were hooked up to the tremie pipe to deliver the annular fill materials.

The borehole was backfilled with 8/12 silica sand (35.0 ft^3) from 1247.3 to 1202.1 ft bgs (Table 7.2-1). A lower seal of 0.375-in. bentonite chips (15.2 ft^3) was then installed from 1202.1 to1184.8 ft bgs. This section includes a 3-ft section of 12-in. casing from 1198.0 to 1201.0 ft bgs that remained downhole after the casing shoe was cut. A 10/20 silica sand filter pack (21.0 ft^3) was placed from 1184.8 to 1165.2 ft bgs, surrounding the screened interval of the well casing. During placement of the filter pack, the screened interval was swabbed and the borehole surged to promote proper setting and compaction. A 20/40 silica sand transition collar was then installed on top of the filter pack from 1165.2 to 1162.4 ft bgs (2.0 ft^3). The volume of silica sand used differed from the calculated amount (2.6 ft^3) by 23% and is most likely because of washouts across the borehole walls.

A bentonite seal consisting of 1427.4 ft^3 of 0.375-in. bentonite chips was installed above the sand collar from 1162.4 to 74.0 ft bgs. The surface seal of Type I Portland cement was completed from 74.0 to 3.0 ft bgs on March 12 with a volume of 137.2 ft^3, 32% less than the calculated volume of 181.7 ft^3.

A length of 24-in. casing was left in the borehole from ground surface to 52.4 ft, which may account for this discrepancy. Well completion per NMED standards was March 12, 2010, at 1157 h.

8.0 POSTINSTALLATION ACTIVITIES

Following well installation at R-29, well development and aquifer testing were performed. The wellhead and surface pad were constructed, a geodetic survey was performed, and a dedicated sampling system was installed. Site-restoration activities will be completed following the final disposition of contained drill cuttings and groundwater, per the NMED-approved waste-disposal decision trees.

8.1 Well Development

Well development was conducted between March 16 and 21, 2010. Well development began with swabbing and bailing water to remove drilling fluids and formation fines in the filter pack and sump. Bailing continued until water clarity visibly improved. Final development was accomplished using a submersible pump.

The bailing tool used was a 4.0-in.-O.D. by 15.0-ft-long carbon-steel bailer with a total capacity of approximately 7 gal. The tool was lowered by wireline using a Semco S1500 pulling unit and repeatedly filled, withdrawn from the well, and dumped into the cuttings pit. A total of 134 gal. of water was bailed between March 16 and 17. The swabbing tool was a 4.5-in.-O.D., 1-in.-thick rubber disc attached to a weighted-steel rod. The swabbing tool was lowered by wireline to 1180 ft bgs and drawn repeatedly upward across the screened interval from 1180 to 1170 ft bgs.

After bailing, a 10-hp, 4-in.-Grundfos submersible pump was installed in the well to a depth of 1170 ft bgs, and pumped at a rate of approximately 4 to 5 gpm from March 18 to 20. Approximately 9875 gal. of water was removed during development.

8.1.1 Well Development Field Parameters

The field parameters turbidity, temperature, potential of hydrogen (pH), dissolved oxygen (DO), oxidation-reduction potential (ORP), and specific conductance were monitored at R-29 during the pumping stage of well development. In addition, water samples were collected for TOC analysis. 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.

Field parameters were measured at well R-29 by collecting aliquots of groundwater from the discharge pipe without the use of a flow-through cell. Backflow problems had been experienced with its use at a previous well, and it had not been replumbed before well development at R-29.

During development, pH varied from 6.71 to 9.68. Temperature varied from 9.11°C to 19.29°C. DO varied from 2.02 to 8.78 mg/L. Specific conductance ranged from 134 to 347 microsiemens per centimeter (µS/cm). Corrected oxidation-reduction potential (Eh) values varied from 43.8 to 220.5 millvolts. Turbidity ranged from 3008 NTU at the beginning of development (immediately after swabbing) to 4.78 NTU at the end.

The final development parameters at R-29 were pH of 6.71, temperature of 16.26°C, specific conductance of 135 µS/cm, and turbidity of 4.98 NTU. Anomalously high pH values recorded during well development may be attributed to improper operation of the pH probe. It should be noted, NTU readings during the 24-h aquifer test ranged between 0.69 and 4.71 NTU. The final TOC concentration was

0.30 mg/L. Table B 1.2-1 in Appendix B presents a summary of field parameters and volumes discharged during development.

8.2 Aquifer Testing

Aquifer pumping tests, including preliminary step-tests and a 24-h aquifer test, were conducted at R-29 between March 22 and 25, 2010, by David Schafer and Associates. Two short duration pumping and recovery intervals (step tests) were conducted on March 22. The objective of the step-tests was to assess the behavior of the system and properly determine the optimal pumping rate for the 24-h test. A 24-h aquifer test was completed on March 24 and 25. A 10-horsepower (hp), 4-in.-diameter Grundfos submersible pump was used to perform the aquifer tests. Approximately 5364 gal. of groundwater was purged during aquifer testing activities. Data analysis and interpretation of the R-29 aquifer tests are presented in Appendix C.

8.3 Dedicated Sampling System Installation

A dedicated sampling system for R-29 was installed on April 23 and 24, 2010. The system utilizes a single 5-hp Franklin Electric motor and a 4-in.-O.D. environmentally retrofitted Grundfos submersible pump. 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 were banded to the pump riser. A dedicated In-Situ Level Troll 500 transducer was installed in one of the tubes, and manual water-level measurements will be collected from the second. Both PVC tubes are equipped with a 1.7-ft section of 0.010-in. slotted screen and a closed bottom. Details of the dedicated sampling system are presented in Figure 8.3-1a. Figure 8.3-1b presents technical notes.

8.4 Wellhead Completion

A reinforced concrete surface pad, 10 ft × 10 ft × 6 in. thick, was installed at the R-29 wellhead. The concrete pad was slightly elevated above the ground surface and crowned to promote runoff. The pad will provide long-term structural integrity for the well. A brass monument marker was embedded in the northwest corner of the pad. A 16-in.-O.D. steel protective casing with a locking lid was installed around the stainless-steel well riser. Four steel bollards, painted yellow for visibility, were set at the outside edges of the pad to protect the well from traffic. They are designed for easy removal to allow access to the well. Details of the wellhead completion are presented in Figure 8.3-1a.

8.5 Geodetic Survey

A licensed professional land surveyor conducted a geodetic survey on June 4, 2010. The survey data conform to Laboratory Information Architecture project standards IA-CB02, “GIS Horizontal Spatial Reference System,” and IA-D802, “Geospatial Positioning Accuracy Standard for A/E/C and Facility Management.” All coordinates are expressed relative to the New Mexico State Plane Coordinate System Central Zone (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 include ground surface elevation near the concrete pad, the top of the brass marker in the concrete pad, the top of the well casing, and the top of the protective casing for the R-29 monitoring well (Table 8.5-1 and Appendix F).

8.6 Waste Management and Site Restoration

Waste generated from the R-29 project includes drilling fluids, purged groundwater, drill cuttings, decontamination water, and contact waste. A summary of the waste characterization samples collected during drilling, construction, and development of the R-29 well is presented in Table 8.6-1.

All waste streams produced during drilling and development activities were sampled in accordance with "Waste Characterization Strategy Form for South Canyon Wells R-29 and R-30 (TA-49, MDA-AB) Regional Groundwater Well Installation and Corehole Drilling" (LANL 2009, 107444).

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 Standard Operating Procedure (SOP) ENV-RCRA SOP-010.0, 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 the drilling fluids are hazardous/nonradioactive or mixed low-level waste, they 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 SOP-011.0, 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 applicable SOPs, removing the polyethylene liner, removing the containment area berms, and backfilling and regrading the containment area, as appropriate.

9.0 DEVIATIONS FROM PLANNED ACTIVITIES

Drilling, sampling, and well construction at R-29 were performed as specified in "Well R-29 Drill Plan–Final, Installation of Well R-29, TA-49, Los Alamos National Laboratory, Revision 1" (North Wind, Inc., 2009, 109456).

10.0 ACKNOWLEDGMENTS

Layne Christensen drilled borehole R-29 and installed the R-29 monitoring well.

Pat Longmire provided the write-up for Groundwater Analytical Results.

Laboratory personnel ran downhole video equipment.

David Schafer and Associates performed the aquifer testing and provided the write-up and data for the Aquifer Testing Report.

Schlumberger Water Services performed geophysical logging of the borehole, and Ned Clayton provided the Schlumberger Geophysical Logging Report.

North Wind, Inc., provided oversight on all preparatory and field-related activities.

11.0 REFERENCES AND MAP DATA SOURCES

11.1 References

The following list includes all documents cited in this report. Parenthetical information following each reference provides the author(s), publication date, and ER ID. This information is also included in text citations. ER ID numbers 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; the U.S. Department of Energy–Los Alamos Site Office; the U.S. Environmental Protection Agency, Region 6; 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 South Canyon Wells R-29 and R-30 (TA-49, MDA-AB) Regional Groundwater Well Installation and Corehole Drilling," Los Alamos, New Mexico. (LANL 2009, 107444)

North Wind Inc., January 25, 2010. "Well R-29 Drill Plan - Final, Installation of Well R-29, TA-49, Los Alamos National Laboratory, Revision 1," plan prepared for Los Alamos National Laboratory, Los Alamos, New Mexico. (North Wind, Inc., 2010, 109456)

11.2 Map Data Sources

Point Feature Locations of the Environmental Restoration Project Database; Los Alamos National Laboratory, Waste and Environmental Services Division, EP2008-0109; 28 February 2008.

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

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

Fences, Los Alamos National Laboratory,KSL Site Support Services, Planning, Locating and Mapping Section, 06 January 2004, as published 04 January 2008.

Paved Road Arcs; Los Alamos National Laboratory, KSL Site Support Services, Planning, Locating and Mapping Section; 06 January 2004; as published 04 January 2008.

Dirt Road Arcs; Los Alamos National Laboratory, KSL Site Support Services, Planning, Locating and Mapping Section; 06 January 2004; as published 04 January 2008.

Structures; Los Alamos National Laboratory, KSL Site Support Services, Planning, Locating and Mapping Section; 06 January 2004; as published 04 January 2008.

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

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

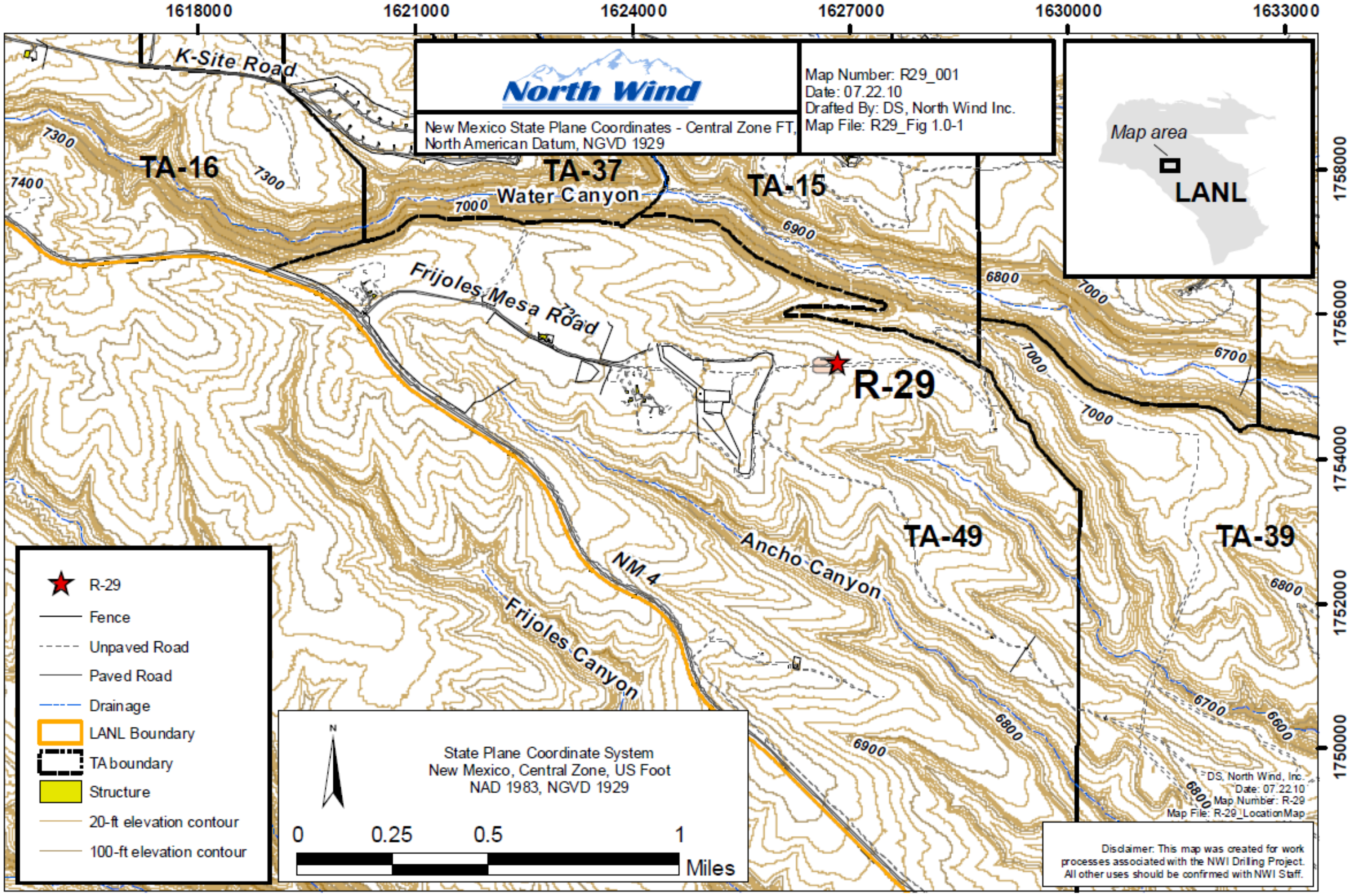

Figure 1.0-1 Location of monitoring well R-29

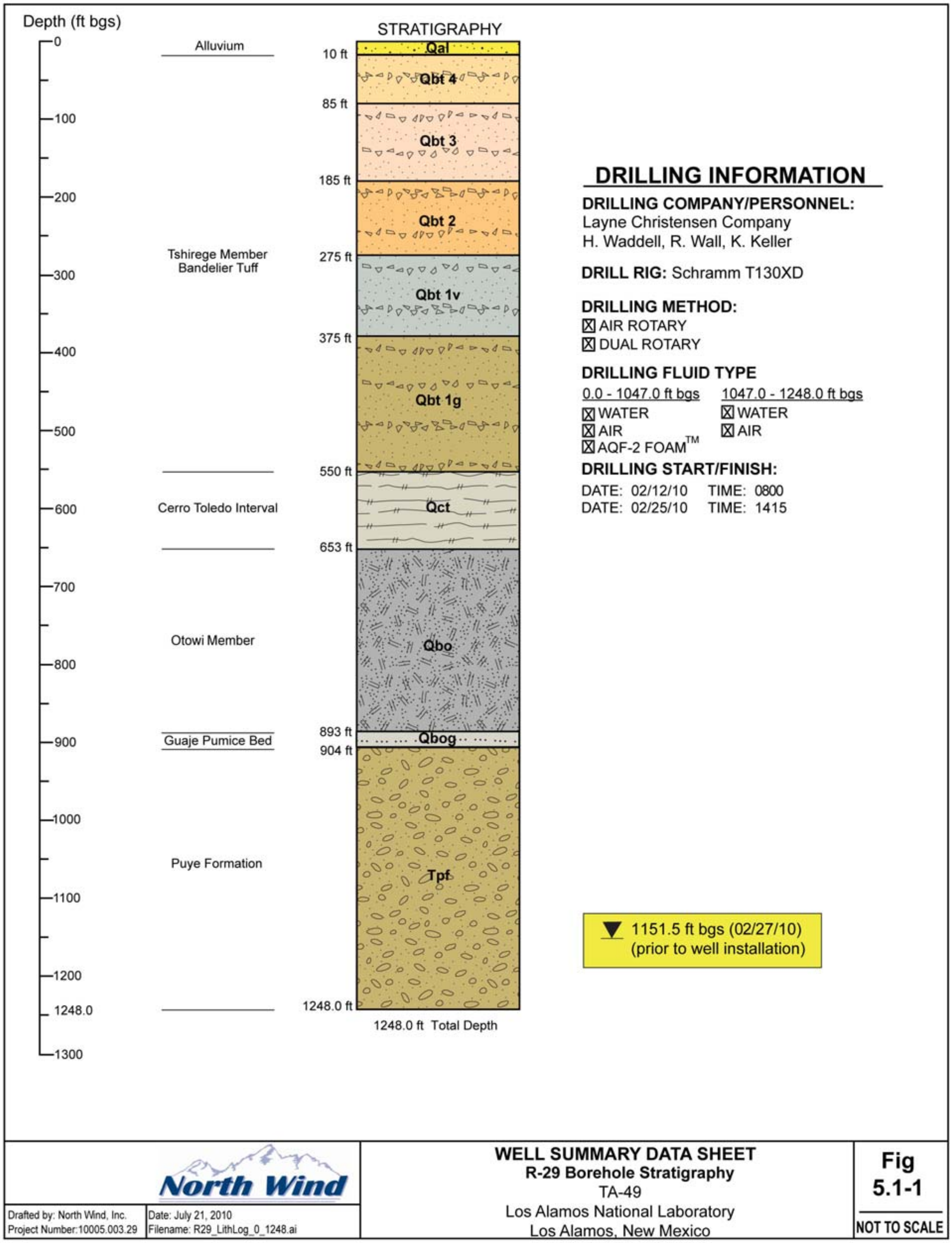

Figure 5.1-1 Monitoring well R-29 borehole stratigraphy

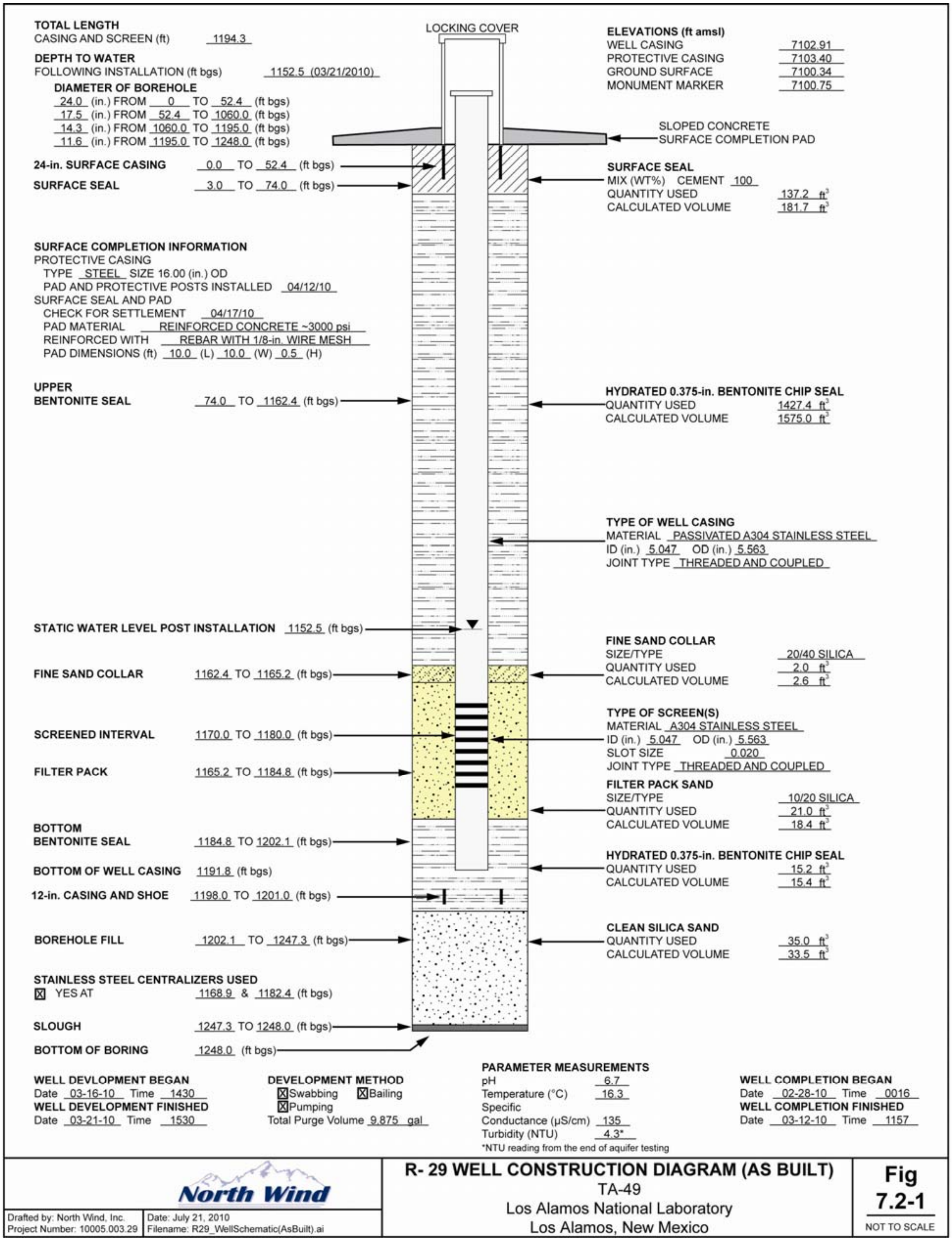

Figure 7.2-1 Monitoring well R-29 as-built well construction diagram

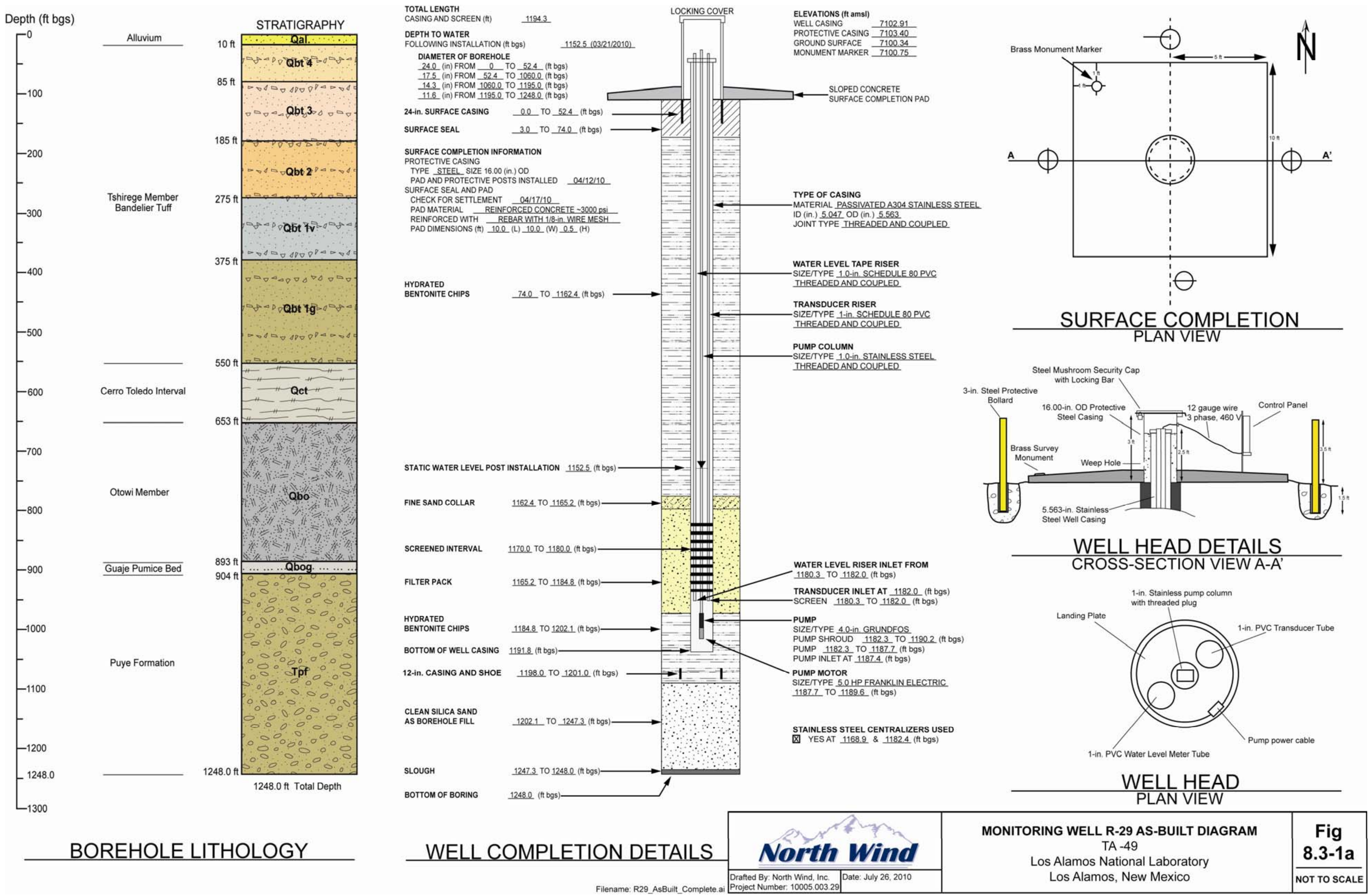

Figure 8.3-1a As-built schematic for monitoring well R-29

R-29 TECHNICAL NOTES

SURVEY INFORMATION[1]

Brass Marker

Northing:	1755383.32 ft
Easting	1626779.91 ft
Elevation	7100.75 ft amsl

Well Casing

Northing:	1755378.87 ft
Easting:	1626782.64 ft
Elevation:	7102.91 ft amsl

BOREHOLE GEOPHYSICAL LOGS

LANL Natural Gamma and Array Induction Logs (02/17/10)
Schlumberger: Hostile Natural Gamma Spectroscopy, Elemental Capture Sonde, Triple Detector Lithodensity, Accelerator Porosity Sonde

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 (discontinued at 1047.0 ft bgs), potable water

MILESTONE DATES

Drilling

Start:	02/12/2010
Finish:	02/25/2010

Well Completion

Start:	02/28/2010
Finish:	03/12/2010

Well Development

Start:	03/16/2010
Finish:	03/21/2010

NOTES:
1) 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: 9875 gallons

Parameter Measurements

pH:	6.7
Temperature:	16.3ºC
Specific Conductance:	135 µS/cm
Turbidity	4.3 NTU*

*NTU reading from the end of aquifer testing

AQUIFER TESTING

Constant Rate Pumping Test

Water Produced:	5,364 gallons
Average Flow Rate:	3.7 gpm
Performed on:	03/22/2010 - 03/25/2010

DEDICATED SAMPLING SYSTEM

Pump Type 10S50-1125CB
Make: Grundfos
Model: B96845812
SN#: P11005208
10.0 U.S. gpm, intake at 1187.4 ft bgs
Environmental Retrofit

Motor
Make: 5 HP Franklin Electric
Model: 2343278602
SN#: 10C14-23-0370

Pump Column
1-in. ID Threaded/Coupled
Schedule 80 Stainless Steel

Transducer Tube
1-in. ID Flush Threaded Schedule 80 PVC with 1.7-ft long 0.010-in. Screen between 1180.3 - 1182.0 ft bgs

Water Level Tube
1-in ID Flush Threaded Schedule 80 PVC
Screen between 1180.3 - 1182.0 ft bgs

Transducer Upper
Installed 04/24/2010
Make: In-Situ
Model: Level Troll 500
SN#: 226939

North Wind

Drafted by: North Wind, Inc.
Project Number: 10005.003.29
Date: July 26, 2010
Filename: R-29_Tech_Specs.ai

R-29 TECHNICAL NOTES
(TA-49)
Los Alamos National Laboratory
Los Alamos, New Mexico

Fig 8.3-1b
NOT TO SCALE

Figure 8.3-1b As-built technical notes for monitoring well R-29

Table 3.1-1
Fluid Quantities Used during R-29 Drilling and Well Construction

Date	Water (gal.)	Cumulative Water (gal.)	AQF-2 Foam (gal.)	Cumulative AQF-2 Foam (gal.)
Drilling				
02/12/10	1200	1200	n/a*	n/a
02/13/10	3500	4700	n/a	n/a
02/14/10	1200	5900	12	n/a
02/15/10	4900	10,800	46	n/a
02/16/10	12,500	23,300	n/a	n/a
02/20/10	6500	29,800	n/a	n/a
02/21/10	5200	35,000	n/a	n/a
02/23/10	800	35,800	n/a	n/a
02/25/10	4500	40,300	n/a	n/a
02/28/10	2100	42,400	n/a	n/a
Well Construction				
03/01/10	4000	46,400	n/a	n/a
03/02/10	14,525	60,925	n/a	n/a
03/03/10	4000	64,925	n/a	n/a
03/04/10	19,950	84,875	n/a	n/a
03/05/10	10,000	94,875	n/a	n/a
03/06/10	27,500	122,375	n/a	n/a
03/07/10	27,000	149,375	n/a	n/a
03/08/10	32,700	182,075	n/a	n/a
03/09/10	17,000	199,075	n/a	n/a
03/11/10	16,600	215,675	n/a	n/a
03/12/10	800	216,475	n/a	n/a
Total Water Volume (gal.)				
R-29	216,475			

* n/a = Not applicable. Foam use terminated at 1047.0 ft bgs during drilling; none used during well construction.

Table 4.2-1
Summary of Groundwater Screening Samples Collected during Drilling and Well Development of Well R-29

Location ID	Sample ID	Date Collected	Collection Depth (ft bgs)	Sample Type	Analysis
Drilling					
R-29	GW29-10-13277	2/21/10	1175	Groundwater (air lifted)	Metals/anions (including perchlorate) HE, VOCs
R-29	GW29-10-13276	2/25/10	1248	Groundwater (air lifted)	Metals/anions (including perchlorate) HE, VOCs
Well Development					
R-29	GW29-10-13271	3/18/10	1170	Groundwater (air lifted)	TOC
R-29	GW29-10-13272	3/19/10	1080	Groundwater (air lifted)	TOC
R-29	GW29-10-13270	3/20/10	1175	Groundwater (air lifted)	TOC, metals/anions

Table 6.0-1
R-29 Video and Geophysical Logging Runs

Date	Depth (ft bgs)	Description
02/17/10	0–972	LANL borehole video log run. Logging before start of casing advance in Puye Formation. Significant wash-out noted in interval ~566–580 ft bgs. The Guaje Pumice Bed was noted at 893 ft bgs. After defoamer was poured downhole to clear residual foam, a water level of 972 ft bgs was observed in the borehole; this water is believed to be accumulated drilling water. There was no evidence of perched water flowing down the borehole walls.
02/17/10	0–1031	LANL natural gamma log run from ground surface to 1031 ft bgs.
02/17/10	0–1031	LANL induction log run. Borehole was logged up successfully from ~1031 ft bgs with no problems. Open borehole from approximately 52.4 ft bgs, bottom of 24-in. casing, to 1031 ft bgs.
02/27/10	0–1248 (TD)	Schlumberger cased hole geophysical log suite: TDL, ECS, APS, and HNGS Logging depths were measured from rig table (kelly bushing), necessitating later corrections to ground level.
02/28/10	0–1248 (TD)	LANL borehole video log run. Camera was run to verify cut-off of 12 in. casing after pumping ~1900 gal. water downhole for visibility. Cut appeared to be successful at planned depth of 1198 ft bgs.

Table 7.2-1
R-29 Monitoring Well Annular Fill Materials

Material	Volume
Upper surface seal: Portland cement	137.2 ft^3
Upper bentonite seal: bentonite chips	1427.4 ft^3
Fine sand collar: 20/40 silica sand	2.0 ft^3
Filter pack: 10/20 silica sand	21.0 ft^3
Lower bentonite seal: bentonite chips	15.2 ft^3
Borehole fill: 8/12 silica sand	35.0 ft^3

Table 8.5-1
R-29 Survey Coordinates

Identification	Northing	Easting	Elevation
R-29 brass cap embedded in pad	1755383.32	1626779.91	7100.75
R-29 ground surface near pad	1755391.80	1626776.38	7100.34
R-29 top of protective casing	1755378.94	1626782.59	7103.40
R-29 top of stainless-steel well casing	1755378.87	1626782.64	7102.91

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

Table 8.6-1
Summary of Waste Samples Collected during Drilling and Development of R-29

Sample ID/Event ID	Date, Time Collected	Description	Sample Matrix
WST29-10-13280/2652	2/23/10, 1207	Trip blank	Liquid
WST29-10-13281/2652	2/23/10, 1207	Decon water	Liquid
WST29-10-13858/2677	3/4/10, 1600	Decon water	Liquid
WST29-10-13859/2677	3/4/10, 1600	Trip blank	Liquid
WST29-10-14052/2693	3/9/10, 1200	Drilling fluids	Liquid
WST29-10-14053/2693	3/9/10, 1200	Trip blank	Liquid
WST29-10-13870/2678	3/18/10, 1045	Decon water	Liquid
WST29-10-13871/2678	3/18/10, 1045	Trip blank	Liquid
WST29-10-15013/2716	3/26/10, 1325	Decon water	Liquid
WST29-10-15014/2716	3/26/10, 1325	Trip blank	Liquid
WST29-10-15378/2724	3/30/10, 1030	Development water	Liquid
WST29-10-15379/2724	3/30/10, 1030	Development water	Liquid
WST29-10-15380/2724	3/30/10, 1030	Development water	Liquid
WST29-10-15381/2724	3/30/10, 1030	Trip blank	Liquid

Appendix A

Borehole R-29 Lithologic Log

Los Alamos National Laboratory
Regional Hydrogeologic Characterization Project
Borehole Lithologic Log

Borehole Identification (ID): R-29	**Technical Area (TA):** 49	**Page:** 1 of 18
Drilling Company: Layne Christensen Co.	**Start Date/Time:** 02/12/10 0800	**End Date/Time:** 02/25/10 1415
Drilling Method: Dual Rotary	**Machine:** Schramm T130XD	**Sampling Method:** Grab
Ground Elevation: 7100.34 ft amsl		**Total Depth:** 1248 ft bgs
Drillers: 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 (SW-SM), moderately to highly weathered, pale brown (10YR6/3) to light brown (10YR5/3), moderately sorted, subangular to subrounded fragments. WR: Fine- to medium-grained alluvial silts and sands with minor gravels including intermediate composition volcanic lithic fragments and pumice fragments, minor quartz and sanidine crystals. Abundant silt. +10F: 20%–30% welded tuff fragments, 10%–20% milky to clear quartz and sanidine crystals. 50%–60% volcanic lithic fragments, with minor Fe-oxide staining. +35F: 15%–20% quartz and sanidine crystals, 15%–20% tuff fragments, 45%–60% minor volcanic lithic fragments. Abundant woody debris noted.	**Qal**	Note: Construction gravel and base-course fill present in cuttings.
10–20	**UNIT 4 OF THE TSHIREGE MEMBER OF THE BANDELIER TUFF:** Tuff, very pale brown (10YR7/3) to very pale brown (10YR8/2), weakly welded, crystal poor with devitrified pumice fragments, volcanic lithics, and quartz and sanidine crystals in an ashy matrix. Pumices have a sugary appearance. +10F: 60%–75% pumice fragments, 10%–25% volcanic lithics, 2%–5% quartz and sanidine crystals (bipyramidal quartz noted). +35F: 15%–20% pumice fragments, 20%–25% volcanic lithics, 45%–65% quartz and sanidine crystals.	**Qbt 4**	Contact between Qal and Qbt 4 was at 10 ft bgs.
20–40	Tuff, very pale brown (10YR8/2) to white (10YR8/1), weakly to nonwelded, crystal poor with devitrified pumice fragments, volcanic lithics, and quartz and sanidine crystals in an ashy matrix. Pumices have a sugary appearance. Reddish-orange to orange-brown oxidation on some pumice fragments. +10F: 10%–25% pumice fragments, 50%–70% volcanic lithics, 5-10% quartz and sanidine crystals (bipyramidal quartz noted). +35F: 5%–15% pumice fragments, 15%–25% volcanic lithics, 60%–65% quartz and sanidine crystals.	**Qbt 4**	

Borehole Identification (ID): R-29	Technical Area (TA): 49	Page: 2 of 18
Drilling Company: Layne Christensen Co.	**Start Date/Time:** 02/12/10 0800	**End Date/Time:** 02/25/10 1415
Drilling Method: Dual Rotary	**Machine:** Schramm T130XD	**Sampling Method:** Grab
Ground Elevation: 7100.34 ft amsl		**Total Depth:** 1248 ft bgs
Drillers: 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
40–60	Tuff, light gray (10YR7/1) to reddish gray (10R5/1), weakly welded, crystal poor with devitrified pumice fragments, volcanic lithics, and quartz and sanidine crystals in an ashy matrix. Pumices have a sugary appearance. Note appearance of purple-gray pumice fragments in 40–45 and 55–60 ft interval. Minor orange-brown oxidation on some pumice fragments. +10F: 55%–65% pumice fragments, 15%–20% volcanic lithics, 15%–20% quartz and sanidine crystals. +35F: 15%–20% pumice fragments, 20%–25% volcanic lithics, 55%–60% quartz and sanidine crystals (bipyramidal quartz noted).	**Qbt 4**	
60–85	Tuff, light gray (10YR7/1) to gray (10YR6/1), weakly welded, crystal poor with devitrified pumice fragments, volcanic lithics, and quartz and sanidine crystals in an ashy matrix. Pumice fragments have a sugary appearance. +10F: 75%–85% pumice fragments, 2%–5% volcanic lithics, 10%–15% quartz and sanidine crystals (bipyramidal quartz noted). +35F: 30%–35% pumice fragments, 5%–10% volcanic lithics, 55%–60% quartz and sanidine crystals (bipyramidal quartz with inclusions noted).	**Qbt 4**	
85–100	**UNIT 3 OF THE TSHIREGE MEMBER OF THE BANDELIER TUFF:** Tuff, white (7.5YR8/1) to light gray (7.5YR7/1), weakly to nonwelded, crystal rich with devitrified pumice fragments, minor volcanic lithics, and quartz and sanidine crystals in an ashy matrix. +10F: 90%–95% pumice fragments, 5%–10% volcanic lithics, trace quartz and sanidine crystals. +35F: 35%–40% pumice fragments, 60%–65% quartz and sanidine crystals, trace volcanic lithics. Evidence of vapor phase cavities in 85–90-ft interval.	**Qbt 3**	Contact between Qbt 4 and Qbt 3 at 85 ft bgs

Borehole Identification (ID): R-29	**Technical Area (TA):** 49	**Page:** 3 of 18
Drilling Company: Layne Christensen Co.	**Start Date/Time:** 02/12/10 0800	**End Date/Time:** 02/25/10 1415
Drilling Method: Dual Rotary	**Machine:** Schramm T130XD	**Sampling Method:** Grab
Ground Elevation: 7100.34 ft amsl		**Total Depth:** 1248 ft bgs
Drillers: 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**
100–110	Tuff, white (7.5YR8/1) to light gray (7.5YR7/1), moderately to weakly welded, crystal rich with devitrified pumice fragments, volcanic lithics, and quartz and sanidine crystals in an ashy matrix. +10F: 10%–20% pumice fragments, 70%–80% volcanic lithics, trace quartz and sanidine crystals. +35F: 25%–30% pumice, 5%–10% volcanic lithics, 60%–65% quartz and sanidine crystals (bipyramidal quartz noted).	**Qbt 3**	
110–130	Tuff, white (7.5YR8/1) to light gray (7.5YR7/1), minor non-welded, crystal rich with devitrified pumice fragments (relatively unconsolidated), volcanic lithics, and quartz and sanidine crystals. +10F: 5%–10% pumice fragments, 10%–30% volcanic lithics, 60%–65% quartz and sanidine crystals. +35F: 5%–10% pumice fragments, 10%–20% volcanic lithics, 70%–75% quartz and sanidine crystals (bipyramidal quartz and inclusions in quartz noted). Note: abundant metal shavings in 125–130-ft interval.	**Qbt 3**	
130–135	Tuff, white (7.5YR8/1) to light gray (7.5YR7/1), weakly welded, crystal rich with devitrified pumice fragments (relatively unconsolidated), volcanic lithics, and quartz and sanidine crystals. +10F: 15% pumice fragments, 80% volcanic lithics, 5% quartz and sanidine crystals. +35F: 5% pumice fragments, 20% volcanic lithics, 75% quartz and sanidine crystals (bipyramidal quartz and inclusions in quartz noted).	**Qbt 3**	
135–160	Tuff, white (7.5YR8/1) to light gray (7.5YR7/1), non-welded, crystal rich with devitrified pumice fragments (relatively unconsolidated), volcanic lithics, and quartz and sanidine crystals. +10F: 5%–15% pumice fragments, 35%–50% volcanic lithics, 35%–45% quartz and sanidine crystals. +35F: 5%–10% pumice fragments, 10%–20% volcanic lithics, 70%–75% quartz and sanidine crystals (bipyramidal quartz and inclusions in quartz noted).	**Qbt 3**	

Borehole Identification (ID): R-29	**Technical Area (TA):** 49	**Page:** 4 of 18
Drilling Company: Layne Christensen Co.	**Start Date/Time:** 02/12/10 0800	**End Date/Time:** 02/25/10 1415
Drilling Method: Dual Rotary	**Machine:** Schramm T130XD	**Sampling Method:** Grab
Ground Elevation: 7100.34 ft amsl		**Total Depth:** 1248 ft bgs
Drillers: 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**
160–175	Tuff, white (7.5YR8/1) to light gray (7.5YR7/1), moderately to weakly welded, crystal rich with devitrified pumice fragments, volcanic lithics, and quartz and sanidine crystals. +10F: 20%–30% pumice fragments, 45%–60% volcanic lithics, 10%–12% quartz and sanidine crystals. +35F: 5%–10% pumice fragments, 10%–20% volcanic lithics, 70%–75% quartz and sanidine crystals (bipyramidal quartz and inclusions in quartz noted). Note: abundant metal shavings in 125–130-ft interval. Orange-brown oxidation on lithic fragments.	**Qbt 3**	
175–185	Tuff, light gray (10YR7/1) to reddish gray (10R5/1), weakly welded, crystal rich with devitrified pumice fragments, volcanic lithics, and quartz and sanidine crystals. Pumices have a sugary appearance. Minor orange-brown oxidation on some pumice fragments. +10F: 65% pumice fragments, 30% volcanic lithics, 5% quartz and sanidine crystals. +35F: 25% pumice fragments, 35% volcanic lithics, 40% quartz and sanidine crystals (bipyramidal quartz noted).	**Qbt 3**	
185–275	**UNIT 2 OF THE TSHIREGE MEMBER OF THE BANDELIER TUFF:** Tuff, light gray (10YR7/1) to gray (10YR6/1), moderately to strongly welded, crystal rich with devitrified pumice, minor volcanic lithics, and quartz and sanidine crystals. Evidence of flattened vesicles in pumice fragments. +10F: 95%–100% pumice fragments, 2%–5% volcanic lithics, trace quartz and sanidine crystals (bipyramidal quartz noted). +35F: 65%–80% pumice fragments, 20%–35% quartz and sanidine crystals, trace volcanic lithics. Minor orange-brown staining on pumice fragments.	**Qbt 2**	Contact between Qbt 3 and Qbt 2 at 185 ft bgs based on cuttings and a pronounced shift in the gamma log. Note: Appearance of strongly welded pumice fragments, indicative of Qbt 2.

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Drilling Company: Layne Christensen Co.	**Start Date/Time:** 02/12/10 0800	**End Date/Time:** 02/25/10 1415
Drilling Method: Dual Rotary	**Machine:** Schramm T130XD	**Sampling Method:** Grab
Ground Elevation: 7100.34 ft amsl		**Total Depth:** 1248 ft bgs
Drillers: 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**
275–295	**UNIT 1 OF THE TSHIREGE MEMBER OF THE BANDELIER TUFF:** Tuff, light gray (10YR7/1) to light brownish gray (10YR6/2), moderately welded with devitrified, porous pumice with evidence of flattening in some fragments, volcanic lithics, and quartz and sanidine crystals. +10F: 60%–75% pumice fragments, 25%–40% volcanic lithics, some quartz and sanidine crystals. +35F: 35%–40% pumice fragments, 5%–10% volcanic lithics, 50%–60% quartz and sanidine crystals (bipyramidal quartz noted).	**Qbt 1v**	Contact between Qbt 2 and Qbt 1v at 275 ft bgs and based on cuttings and a pronounced shift in the gamma log.
295–300	Tuff, light gray (10YR7/1), weakly welded, white (7.5YR8/1) with devitrified pumice fragments, volcanic lithics, and quartz and sanidine crystals. Appears to be some evidence of vapor-phase crusts on phenocrysts. +10F: 35% pumice fragments, 50% volcanic lithics, 15% quartz and sanidine crystals. +35F: 30% pumice fragments, 25% volcanic lithics, 45% quartz and sanidine crystals (bipyramidal quartz and inclusions in quartz noted). Some metal scrapings in +10 fraction.	**Qbt 1v**	
300–305	Tuff, light gray (10YR7/1), weakly welded, white (7.5YR8/1) with devitrified pumice fragments, volcanic lithics, and quartz and sanidine crystals. Appears to be some evidence of vapor-phase crusts on phenocrysts. +10F: 45% pumice fragments, 40% volcanic lithics, 15% quartz and sanidine crystals. +35F: 30% pumice fragments, 25% volcanic lithics, 45% quartz and sanidine crystals (bipyramidal quartz and inclusions in quartz noted).	**Qbt 1v**	
305–325	Tuff, light gray (10YR7/1), weakly welded, white (7.5YR8/1) with devitrified pumice fragments, volcanic lithics, and quartz and sanidine crystals. Appears to be some evidence of vapor-phase crusts on phenocrysts. +10F: 30%–35% pumice fragments, 40%–50% volcanic lithics, 15% quartz and sanidine crystals. +35F: 30% pumice fragments, 25% volcanic lithics, 45% quartz and sanidine crystals (bipyramidal quartz and inclusions in quartz noted).	**Qbt 1v**	

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Drilling Method: Dual Rotary	**Machine:** Schramm T130XD		**Sampling Method:** Grab
Ground Elevation: 7100.34 ft amsl			**Total Depth:** 1248 ft bgs
Drillers: 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**
325–335	Tuff, light gray (10YR7/1), weakly welded, white (7.5YR8/1) with devitrified pumice fragments, volcanic lithics, and quartz and sanidine crystals. Appears to be some evidence of vapor-phase crusts on phenocrysts. Pumice fragments contain relatively more crystals than above and appear more fibrous and porous. Some orange to orange-brown oxidation on pumice fragments. +10F: 35%–45% pumice fragments, 40%–45% volcanic lithics, 10%–15% quartz and sanidine crystals. +35F: 40%–45% pumice fragments, 15%–20% volcanic lithics, 40%–45% quartz and sanidine crystals (bipyramidal quartz and inclusions in quartz noted).	**Qbt 1v**	
335–360	Tuff, light gray (10YR7/1), weakly welded, white (7.5YR8/1) to pale brown (10YR6/3) with devitrified pumice fragments, volcanic lithics, and quartz and sanidine crystals. Appears to be some evidence of vapor-phase crusts on phenocrysts. Pumice fragments appear fibrous and porous. Some orange to orange-brown oxidation on pumice fragments. +10F: 30%–35% pumice fragments, 45%–60% volcanic lithics, 2%–5% quartz and sanidine crystals. +35F: 40%–45% pumice fragments, 15%–20% volcanic lithics, 40%–45% quartz and sanidine crystals (bipyramidal quartz and inclusions in quartz noted).	**Qbt 1v**	
360–375	Tuff, light gray (10YR7/1), weakly welded, white (7.5YR8/1) and pale brown (10YR6/3) to pink (7.5YR7/4) with devitrified pumice fragments, volcanic lithics, and quartz and sanidine crystals. Appears to be some evidence of vapor-phase crusts on phenocrysts. Pumice fragments appear fibrous and porous and relatively crystal rich. Some orange to orange-brown oxidation on pumice fragments. +10F: 55%–65% pumice fragments, 35%–40% volcanic lithics, trace-2% quartz and sanidine crystals. +35F: 55%–65% pumice fragments, 5%–10% volcanic lithics, 25%–30% quartz and sanidine crystals (bipyramidal quartz and inclusions in quartz noted).	**Qbt 1v**	

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Drilling Company: Layne Christensen Co.	**Start Date/Time:** 02/12/10 0800	**End Date/Time:** 02/25/10 1415
Drilling Method: Dual Rotary	**Machine:** Schramm T130XD	**Sampling Method:** Grab
Ground Elevation: 7100.34 ft amsl		**Total Depth:** 1248 ft bgs
Drillers: 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
375–415	Tuff, white (10YR8/1) to light gray (10YR7/1), nonwelded with vitric fibrous/porous, pumice fragments; minor volcanic lithics; and quartz and sanidine crystals. +10F: 75%–95% pumice fragments, 5%–15% volcanic lithics, trace quartz and sanidine crystals. +35F: 70%–95% pumice fragments, trace-5% volcanic lithics, 5%–25% quartz and sanidine crystals (bipyramidal quartz, smoky quartz, and glass shards noted).	**Qbt 1g**	Contact between Qbt 1g and Qbt 1g at 375 ft bgs based on first appearance of vitric pumices in cuttings and a pronounced shift in the gamma log. Note: Appearance of fibrous, porous nonwelded pumice fragments.
415–430	Tuff, light gray (10YR7/1) to dark gray (10YR4/1), nonwelded with vitric fibrous/porous, pumice fragments; volcanic lithics; and quartz and sanidine crystals. +10F: 50%–65% pumice fragments, 35%–50% volcanic lithics, 5% to no quartz and sanidine crystals. +35F: 45%–65% pumice fragments, 25%–30% volcanic lithics, 5%–10% quartz and sanidine crystals (smoky quartz noted).	**Qbt 1g**	
430–440	Tuff, white (10YR8/1) to light gray (10YR7/1), non-welded with vitric fibrous/porous, pumice fragments, minor volcanic lithics, and quartz and sanidine crystals. +10F: 90%–95% pumice fragments, 5%–10% volcanic lithics, no quartz and sanidine. +35F: 75%–80% pumice fragments, 5%–10% volcanic lithics, 10%–15% quartz and sanidine.	**Qbt 1g**	
440–465	Tuff, white (10YR8/1) to light gray (10YR7/1), non-welded with vitric fibrous/porous pumice fragments, volcanic lithics, and quartz and sanidine crystals. +10F: 60%–75% pumice fragments, 25%–40% volcanic lithics, no quartz and sanidine. +35F: 55%–70% pumice fragments, 15%–20% volcanic lithics, 10%–15% quartz and sanidine (smokey quartz noted).	**Qbt 1g**	

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Drilling Method: Dual Rotary	**Machine:** Schramm T130XD	**Sampling Method:** Grab
Ground Elevation: 7100.34 ft amsl		**Total Depth:** 1248 ft bgs
Drillers: 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**
465–500	Tuff, very pale brown (10YR8/2) to pink (7.5YR7/3), non-welded with vitric fibrous/porous pumice fragments, minor volcanic lithics, and quartz and sanidine crystals. +10F: 80%–95% pumice fragments, 5%–20% volcanic lithics, no quartz and sanidine. +35F: 65%–75% pumice fragments, 5%–10% volcanic lithics, 15%–20% quartz and sanidine (bipyramidal and smoky quartz noted). Minor oxidation on pumice fragments.	**Qbt 1g**	
500–520	Tuff, pinkish white (7.5YR8/2) to gray (5YR5/1), white (5YR8/1) to light reddish brown (5YR6/3) nonwelded with vitric fibrous/porous pumice fragments, volcanic lithic fragments, quartz and sanidine crystals. +10F: 60%–75% pumice fragments, 25%–40% lithics, trace to no quartz and sanidine crystals. +35F: 70%–85% pumice fragments, 2%–5% lithics, 10%–20% quartz and sanidine (bipyramidal quartz and minor inclusions in quartz noted). Minor oxidation on pumice fragments.	**Qbt 1g**	
520–525	Tuff, light reddish brown (5YR6/3) to gray (5YR5/1), nonwelded with vitric fibrous/porous pumice fragments, abundant volcanic lithic fragments (relative to above), quartz and sanidine crystals. +10F: 60% pumice fragments, 40% volcanic lithic fragments, no quartz and sanidine. +35F: 70% pumice fragments, 5% volcanic lithics, 25% quartz and sanidine (bipyramidal quartz noted). Minor oxidation on pumice fragments.	**Qbt 1g**	
525–530	Tuff, pinkish white (5YR8/2) to light reddish brown (5YR6/3), nonwelded with vitric fibrous/porous pumice fragments, volcanic lithic fragments, quartz and sanidine crystals. +10F: 85% pumice fragments, 15% lithics, no quartz and sanidine crystals. +35F: 75% pumice fragments, 5% lithics, 20% quartz and sanidine (bipyramidal quartz and minor inclusions in quartz noted). Minor oxidation on pumice fragments.	**Qbt 1g**	

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Drilling Method: Dual Rotary	**Machine:** Schramm T130XD	**Sampling Method:** Grab
Ground Elevation: 7100.34 ft amsl		**Total Depth:** 1248 ft bgs
Drillers: 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
530–540	Tuff, white (5YR8/1) to light reddish brown (5YR6/3), nonwelded with vitric fibrous/porous pumice fragments (some with a sugary texture), minor volcanic lithic fragments, quartz and sanidine crystals. +10F: 90%–95% pumice fragments, 5%–10% volcanic lithics, no quartz and sanidine. +35F: 75%–85% pumice fragments, 2%–5% volcanic lithics, 10%–20% quartz and sanidine (bipyramidal quartz noted).	**Qbt 1g**	
540–545	Tuff, white (5YR8/1) to light gray 5YR(7/1), non-welded with vitric fibrous/porous pumice fragments (some with a sugary texture), volcanic lithic fragments, quartz and sanidine crystals. +10F: 85% pumice fragments, 15% volcanic lithics, no quartz and sanidine. +35F: 80% pumice fragments, 5% volcanic lithics, 15% quartz and sanidine (bipyramidal quartz and smokey quartz noted).	**Qbt 1g**	
545–550	Tuff, white (5YR8/1) to light reddish brown (5YR6/3), nonwelded with vitric fibrous/porous pumice fragments, minor volcanic lithic fragments, quartz and sanidine crystals. +10F: 90%–95% pumice fragments, 5%–10% volcanic lithics, no quartz and sanidine. +35F: 75%–85% pumice fragments, 2%–5% volcanic lithics, 10%–20% quartz and sanidine (bipyramidal quartz noted).	**Qbt 1g**	
550–565	**CERRO TOLEDO INTERVAL:** Volcaniclastic sediments, very pale brown (10YR8/2) to light gray (10YR7/1), moderately sorted, poorly graded with sand (GM), fine to coarse sand, grains angular to subrounded. +10F: detrital constituents (up to 10 mm) composed of 35%–60% felsic-intermediate composition volcanic lithics (including appearance of obsidian), 40%–65% white to light reddish brown fibrous pumice fragments, trace to no quartz and sanidine crystals. +35F: 50%–55% volcanic lithics, 30%–35% pumice fragments, 10%–15% quartz and sanidine.	**Qct**	Contact between Qbt 1g and upper Qct at 550 ft bgs corresponds with significant shift on gamma log.

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Drilling Method: Dual Rotary	**Machine:** Schramm T130XD	**Sampling Method:** Grab
Ground Elevation: 7100.34 ft amsl		**Total Depth:** 1248 ft bgs
Drillers: 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
565–570	Volcaniclastic sediments, light gray (5YR7/1) to gray (5YR6/1), moderately sorted, poorly graded with sand (GM), fine to coarse sand, grains angular to subrounded. +10F: detrital constituents (up to 5 mm) composed of 75% felsic-intermediate composition volcanic lithics, 25% white to light reddish brown fibrous, vitric and devitrified pumice fragments, no quartz and sanidine crystals. +35F: 60% volcanic lithics, 20% pumice fragments, 20% quartz and sanidine.	**Qct**	
570–595	Volcaniclastic sediments, light gray (7.5YR7/1) to dark gray (5YR4/1), poorly sorted, well-graded with sand (GW), fine to coarse sand, grains angular to subrounded. +10F: detrital constituents (up to 15 mm) include 85%–90% felsic-intermediate composition volcanic lithics (including obsidian and dacite), 10%–15% white to reddish-orange vitric and devitrified pumice fragments, trace to no quartz and sanidine. +35F: 60%–70% volcanic lithics, 15%–20% pumice fragments, 10%–20% quartz and sanidine. Orange-brown oxidation on most pumice fragments.	**Qct**	
595–600	Volcaniclastic sediments, white (5YR8/1) to light gray (7.5YR7/1), poorly sorted, well-graded with sand (GW), fine to coarse sand, grains subangular to subrounded. +10F: detrital constituents (up to 15 mm) include 20% felsic-intermediate composition volcanic lithics, 80% white to light gray vitric and devitrified pumice. +35F: 30% volcanic lithics, 60% pumice fragments, 10% quartz and sanidine.	**Qct**	
600–620	Volcaniclastic sediments, light gray (7.5YR7/1) to dark gray (5YR4/1), poorly sorted, well graded with sand (GW), fine to coarse sand, grains subangular to subrounded. +10F: detrital constituents (up to 10 mm) include 80%–90% felsic-intermediate composition volcanic lithics (including dacite), 10%–20% white to light gray vitric and devitrified pumice fragments. +35F: 55%–60% volcanic lithics, 25%–30% pumice fragments, 10%–20% quartz and sanidine. Orange-brown oxidation on most clasts.	**Qct**	

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Drilling Method: Dual Rotary	**Machine:** Schramm T130XD	**Sampling Method:** Grab
Ground Elevation: 7100.34 ft amsl		**Total Depth:** 1248 ft bgs
Drillers: 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
620–625	Volcaniclastic sediments, dark gray (5YR4/1), moderately sorted, well-graded with sand (GW), medium to coarse sand, grains subangular to subrounded. +10F: detrital constituents (up to 5 mm) include 95% felsic-intermediate composition volcanic lithics (including dacite), 5% light gray to orange-brown vitric and devitrified pumice fragments. +35F: 70% volcanic lithics, 20% pumice fragments, 10% quartz and sanidine. Orange-brown oxidation on most clasts.	**Qct**	
625–653	Volcaniclastic sediments, light gray (7.5YR7/1) to brown (7.5YR5/2), moderately sorted, well-graded with sand (GW), fine to coarse sand, grains subangular to subrounded. +10F: detritral constituents (up to 5 mm) composed of 60%–70% felsic-intermediate composition volcanic lithics (including dacite), 30%–40% white to light reddish brown vitric and devitrified pumice fragments, trace tuffaceous sandstone. +35F: 50%–55% volcanic lithics, 30%–35% pumice fragments, 10%–15% quartz and sanidine.	**Qct**	
653–735	**OTOWI MEMBER OF THE BANDELIER TUFF:** Tuff, light gray (7.5YR7/1) to light brown (7.5YR6/4), weakly to nonwelded with light gray to orange-brown fibrous vitric pumice fragments, varieties of aphanitic to porphyritic intermediate volcanic lithics (up to 10 mm), and crystals. WR: ashy/sandy texture. +10F: 35%–55% pumice fragments, 45%–65% volcanic lithics. +35F: 50%–65% pumice fragments, 15%–35% volcanic lithics, 15%–20% quartz and sanidine crystals (trace obsidian and minor red oxidized rock fragments noted).	**Qbo**	Contact between upper Qct and Qbo at 653 ft bgs and corresponds with significant shift on gamma log.

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Drilling Method: Dual Rotary	**Machine:** Schramm T130XD		**Sampling Method:** Grab
Ground Elevation: 7100.34 ft amsl			**Total Depth:** 1248 ft bgs
Drillers: 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**
735–760	Tuff, white (7.5YR8/1) to gray (7.5YR6/1), non-welded with light gray to orange-brown fibrous vitric pumice fragments, varieties of aphanitic to porphyritic intermediate volcanic lithics including dacite (up to 20–25 mm), and crystals. WR: ashy/sugary texture. +10F: 25%–40% pumice fragments, 60%–75% volcanic lithics. (Trace obsidian). +35F: 40%–60% pumice fragments, 20%–35% volcanic lithics, 15%–25% quartz and sanidine crystals (minor red oxidized rock fragments noted).	**Qbo**	
760–775	Tuff, light gray (7.5YR7/1) to pinkish gray (7.5YR7/2), nonwelded with light gray to orange-brown fibrous vitric pumice fragments, varieties of aphanitic to porphyritic intermediate volcanic lithics including dacite (up to 10 mm), and crystals. WR: No sandy texture. +10F: 55%–65% pumice fragments, 35%–45% volcanic lithics, trace quartz and sanidine crystals. +35F: 55%–65% pumice fragments, 10%–15% volcanic lithics (including red oxidized fragments), 15%–20% quartz and sanidine crystals.	**Qbo**	
775–780	Tuff, pinkish gray (7.5YR6/2), nonwelded with light gray to orange-brown fibrous vitric pumice fragments, varieties of aphanitic to porphyritic intermediate volcanic lithics including dacite (up to 20 mm), and crystals. WR: ashy/sugary texture. +10F: 20% pumice fragments, 80% volcanic lithics, trace quartz and sanidine crystals. +35F: 40% pumice fragments, 30% volcanic lithics, 30% quartz and sanidine.	**Qbo**	
780–785	No cuttings returned in this interval.		

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Ground Elevation: 7100.34 ft amsl		**Total Depth:** 1248 ft bgs
Drillers: 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**
785–800	Tuff, pale brown (10YR6/3) to dark gray (7.5YR4/1), nonwelded with light gray to orange-brown fibrous vitric pumice fragments, varieties of aphanitic to porphyritic intermediate volcanic lithics including dacite (up to 20 mm), and crystals. WR: sugary texture. +10F: 25%–30% pumice fragments, 70%–75% volcanic lithics (including red oxidized fragments). +35F: 45%–55% pumice fragments, 25%–35% volcanic lithics, 10%–30% quartz and sanidine crystals.	**Qbo**	
800–815	Tuff, pale brown (10YR6/3) to dark gray (7.5YR4/1), nonwelded with light gray to orange-brown fibrous vitric pumice fragments, varieties of aphanitic to porphyritic intermediate volcanic lithics including dacite (up to 20 mm), and crystals. WR: Minor significant texture. +10F: 25%–35% pumice fragments, 65%–75% volcanic lithics (including red oxidized fragments). +35F: 60%–65% pumice fragments, 25%–30% volcanic lithics, 5%–15% quartz and sanidine crystals.	**Qbo**	
815–825	Tuff, pale brown (10YR6/3) to dark gray (7.5YR4/1), nonwelded with light gray to orange-brown fibrous vitric pumice fragments, varieties of aphanitic to porphyritic intermediate volcanic lithics including dacite (up to 5-mm), and crystals. WR: sugary texture. +10F: 35%–40% pumice fragments, 60%–65% volcanic lithics (including red oxidized fragments). +35F: 60%–65% pumice fragments, 25%–30% volcanic lithics, 5%–15% quartz and sanidine crystals.	**Qbo**	
825–870	Tuff, pale brown (10YR6/3) to dark gray (7.5YR4/1), non-welded with light gray to orange-brown fibrous vitric pumice fragments, varieties of aphanitic to porphyritic intermediate volcanic lithics including dacite (up to 20%–25 mm), and crystals. WR: sugary texture. +10F: 20%–35% pumice fragments, 65%–80% volcanic lithics (including red oxidized fragments). Minor tuffaceous sandstone. Trace to no quartz and sanidine crystals. +35F: 40%–55% pumice fragments, 30%–40% volcanic lithics, 5%–20% quartz and sanidine crystals.	**Qbo**	

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Drilling Method: Dual Rotary	**Machine:** Schramm T130XD	**Sampling Method:** Grab
Ground Elevation: 7100.34 ft amsl		**Total Depth:** 1248 ft bgs
Drillers: 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
870–875	Tuff as above, higher pumice content in +35F fraction to 65%–70% pumice fragments.	**Qbo**	
875–880	Tuff, pale brown (10YR6/3) to dark gray (7.5YR4/1), nonwelded with light gray to orange-brown fibrous vitric pumice fragments, varieties of aphanitic to porphyritic intermediate volcanic lithics including dacite (up to 20–25 mm), and crystals. WR: sugary texture. +10F: 20%–35% pumice fragments, 65%–80% volcanic lithics (including red oxidized fragments). Minor tuffaceous sandstone. Trace to no quartz and sanidine crystals. +35F: 40%–55% pumice fragments, 30%–40% volcanic lithics, 5%–20% quartz and sanidine crystals.	**Qbo**	
880–893	Tuff as above, no sugary texture.	**Qbo**	
893–904	**GUAJE PUMICE BED OF THE OTOWI MEMBER OF THE BANDELIER TUFF:** Tuff, pale brown (10YR6/3) to dark gray (7.5YR4/1), light gray to orange-brown fibrous, vitric pumice fragments, varieties of aphanitic to porphyritic intermediate volcanic lithics including dacite (up to 20–25 mm), and crystals. WR: sugary texture. +10F: 20%–35% pumice fragments, 65%–80% volcanic lithics (including dacite and red oxidized fragments). Minor tuffaceous sandstone. Trace to no quartz and sanidine crystals. +35F: 40%–55% pumice fragments, 30%–40% volcanic lithics, 5%–20% quartz and sanidine crystals.	**Qbog**	Contact between Qbo and Qbog at 893 ft bgs based on gamma log and video log observations.

Borehole Identification (ID): R-29	**Technical Area (TA):** 49	**Page:** 15 of 18
Drilling Company: Layne Christensen Co.	**Start Date/Time:** 02/12/10 0800	**End Date/Time:** 02/25/10 1415
Drilling Method: Dual Rotary	**Machine:** Schramm T130XD	**Sampling Method:** Grab
Ground Elevation: 7100.34 ft amsl		**Total Depth:** 1248 ft bgs
Drillers: 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**
904–935	**PUYE FORMATION:** Volcaniclastic sediments, light gray (5YR7/1) to reddish gray (2.5YR6/1), poorly sorted, well-graded with minor sand (GW), grains subangular to subrounded (up to 25 mm). +10F: 85%–97% aphanitic to porphyritic felsic-intermediate composition volcanic lithics (including dacite), 3%–15% pumice fragments. Minor tuffaceous sandstone and siltstone. +35F: 70%–85% volcanic lithics, 5%–10% pumice fragments, 5%–20% quartz and sanidine crystals.	**Tpf**	Contact between Qbog and Tpf at 904 ft bgs corresponds with major shift on gamma log as well as shift in borehole structure and texture in video log. At 904 ft bgs there is a significant change in color, clast size (up to 20–30 mm), and composition (loss of pumice).
935–940	Volcaniclastic sediments, light gray (5YR7/1) to reddish gray (2.5YR6/1), well sorted, poorly graded with sand (GP), grains subangular to subrounded (up to 2–5 mm). +10F: 97% Volcaniclastic sediments, light gray (5YR7/1) to reddish gray (2.5YR6/1), poorly sorted, well-graded with minor sand (GW), grains subangular to subrounded (up to 25 mm). +10F: 85%–97% aphanitic to porphyritic felsic-intermediate composition volcanic lithics (including dacite), 3%–15% pumice fragments. Minor tuffaceous sandstone and siltstone. +35F: 70%–85% volcanic lithics, 5%–10% pumice fragments, 5%–20% quartz and sanidine crystals, aphanitic to porphyritic felsic-intermediate composition volcanic lithics (including dacite), 3% pumice fragments, trace tuffaceous sandstone. +35F: 40% volcanic lithics, 15% pumice fragments, 45% quartz and sanidine crystals.	**Tpf**	Massive deposits of cobbles and boulders were observed in the Puye Formation in video log. The cuttings descriptions provided here represent milled or pulverized material circulated to the surface during drilling.

Borehole Identification (ID): R-29	**Technical Area (TA):** 49	**Page:** 16 of 18	
Drilling Company: Layne Christensen Co.	**Start Date/Time:** 02/12/10 0800	**End Date/Time:** 02/25/10 1415	
Drilling Method: Dual Rotary	**Machine:** Schramm T130XD	**Sampling Method:** Grab	
Ground Elevation: 7100.34 ft amsl		**Total Depth:** 1248 ft bgs	
Drillers: 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**
940–1000	Volcaniclastic sediments, light gray (7.5YR7/1) to reddish brown (2.5YR4/3), poorly sorted, well-graded with sand (GW), grains subangular to subrounded (up to 20–25 mm). +10F: 100% aphanitic to porphyritic felsic-intermediate composition volcanic lithics (including dacite), trace to no pumice fragments. Minor tuffaceous sandstone. +35F: 65%–90% volcanic lithics, 3%–5% pumice fragments, 5%–15% quartz and sanidine crystals.	**Tpf**	
1000–1015	Volcaniclastic sediments, light gray (7.5YR7/1) to reddish brown (2.5YR5/4), poorly sorted, well-graded with sand (GW) and silty coating on some clasts, grains subangular to subrounded (up to 20 mm). +10F: 95%–97% aphanitic to porphyritic felsic-intermediate composition volcanic lithics (including dacite), 3%–5% pumice fragments, trace tuffaceous sandstone. +35F: 65%–85% volcanic lithics, 5%–10% pumice fragments, 5%–10% quartz and sanidine crystals.	**Tpf**	
1015–1055	Volcaniclastic sediments, light gray (5YR7/1) to light reddish brown (2.5YR7/3), poorly sorted, well-graded with sand (GW), grains subangular to subrounded (up to 20–25 mm). +10F: 97%–100% aphanitic to porphyritic felsic-intermediate composition volcanic lithics (including dacite), 3% to no pumice fragments and tuffaceous sandstone. +35F: 85%–93% volcanic lithics, 1%–3% pumice fragments, 4%–15% quartz and sanidine crystals.	**Tpf**	
1055–1065	Volcaniclastic sediments, light gray (5YR7/1) to light reddish brown (2.5YR5/3), poorly sorted, well-graded with sand (GW), grains subangular to subrounded (up to 5–10 mm). WR: sandy texture. +10F: 95%–97% aphanitic to porphyritic felsic-intermediate composition volcanic lithics (including dacite), 3%–5% pumice fragments and tuffaceous sandstone. +35F: 85%–93% volcanic lithics, 1%–3% pumice fragments, 4%–15% quartz and sanidine crystals.	**Tpf**	

Borehole Identification (ID): R-29	**Technical Area (TA):** 49	**Page:** 17 of 18
Drilling Company: Layne Christensen Co.	**Start Date/Time:** 02/12/10 0800	**End Date/Time:** 02/25/10 1415
Drilling Method: Dual Rotary	**Machine:** Schramm T130XD	**Sampling Method:** Grab
Ground Elevation: 7100.34 ft amsl		**Total Depth:** 1248 ft bgs
Drillers: 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**
1065–1070	Volcaniclastic sediments, light gray (5YR7/1) to light reddish brown (2.5YR7/3), poorly sorted, well-graded with sand (GW), grains subangular to subrounded (up to 20 mm). +10F: 100% aphanitic to porphyritic felsic-intermediate composition volcanic lithics (including dacite). +35F: 98% volcanic lithics, 2% pumice fragments, trace quartz and sanidine crystals.	**Tpf**	
1070–1075	Volcaniclastic sediments, light gray (5YR7/1) to light reddish brown (2.5YR5/3), poorly sorted, well graded with sand (GW), grains subangular to subrounded (up to 5 mm). WR: sandy texture. +10F: 95% aphanitic to porphyritic felsic-intermediate composition volcanic lithics (including dacite), 5% pumice fragments and tuffaceous sandstone. +35F: 95% volcanic lithics, 1% pumice fragments, 4% quartz and sanidine crystals.	**Tpf**	
1075–1195	Volcaniclastic sediments, light gray (5YR7/1) to light reddish brown (2.5YR7/3), poorly to moderately sorted, well graded with sand (GW-GP), grains subangular to subrounded (up to 20–25 mm). +10F: 95%–100% aphanitic to porphyritic felsic-intermediate composition volcanic lithics (including dacite), 5% to no pumice fragments and tuffaceous sandstone. +35F: 90%–100% volcanic lithics, 0%–5% pumice fragments, 0%–5% quartz and sanidine crystals.	**Tpf**	
1195–1225	Volcaniclastic sediments, light gray (5YR7/1) to light reddish brown (2.5YR7/3), moderately to well sorted, poorly graded with minor coarse sand (GP), grains subangular to subrounded (up to 5 mm). +10F: 95%–100% aphanitic to porphyritic felsic-intermediate composition volcanic lithics (including dacite), 5% to no pumice fragments and tuffaceous sandstone. +35F: 90%–100% volcanic lithics, 0%–5% pumice fragments, 0%–5% quartz and sanidine crystals.	**Tpf**	

Borehole Identification (ID): R-29		Technical Area (TA): 49		Page: 18 of 18
Drilling Company: Layne Christensen Co.		**Start Date/Time:** 02/12/10 0800		**End Date/Time:** 02/25/10 1415
Drilling Method: Dual Rotary		**Machine:** Schramm T130XD		**Sampling Method:** Grab
Ground Elevation: 7100.34 ft amsl				**Total Depth:** 1248 ft bgs
Drillers: 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**
1225–1248	Volcaniclastic sediments, light gray (5YR7/1) to light reddish brown (2.5YR5/3), poorly sorted, well-graded with sand (GW), grains subangular to subrounded (up to 5–10 mm). +10F: 95%–100% aphanitic to porphyritic felsic-intermediate composition volcanic lithics (including dacite), 5% to no pumice fragments and tuffaceous sandstone. +35F: 90%–100% volcanic lithics, 0%–5% pumice fragments, 0%–5% quartz and sanidine crystals.		**Tpf**	Bottom of borehole at 1248 ft bgs.

Abbreviations

10YR6/3 = Munsell soil color notation where hue, value, and chroma are expressed (e.g., hue=10YR, value=6, and chroma=3).

GW = well graded

GP = poorly graded

Qal = Quaternary Alluvium

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

Qbt 3 = Unit 2 of the Tshirege Member of the Bandelier Tuff

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

Tpf = Puye Formation

SM = silty sands, sand-silt mixtures

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

WR = whole rock

Appendix B

Groundwater Analytical Results

B-1.0 SAMPLING AND ANALYSIS OF GROUNDWATER AT R-29

Five screening groundwater samples were collected during drilling and development at well R-29 at Los Alamos National Laboratory's (LANL's or the Laboratory's).

- Two samples were collected during drilling at 1175.0 and 1248.0 ft below ground surface (bgs) from regional saturation within the Puye Formation. Aliquots of these samples were submitted to an off-site laboratory for high explosive (HE) compounds, volatile organic compounds (VOCs), and metals analyses. Aliquots were also submitted to the Laboratory's Earth and Environmental Sciences Group 14 (EES-14) laboratory for metals and anions (including perchlorate) analyses.
- Three samples were collected during development at R-29 from the well screen at 1170.0 to 1180.0 ft bgs in the Puye Formation and analyzed for total organic carbon (TOC), two by EES-14 and one by an off-site laboratory; the third sample was also analyzed by EES-14 for inorganic solutes.

B-1.1 Analytical Techniques

B-1.1.1 EES-14 Analytical Techniques

Groundwater samples were filtered using 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-screening samples were analyzed using techniques specified by the U.S. Environmental Protection Agency (EPA) methods for water analyses. Ion chromatography (IC) (EPA Method 300, Revision 2.1) was the analytical method for bromide, chloride, fluoride, nitrate, nitrite, oxalate, perchlorate, phosphate, and sulfate. Total carbonate alkalinity (EPA Method 310.1) was measured using standard titration techniques. The instrument detection limit for perchlorate was 0.005 ppm (EPA Method 314.0, Revision 1). Inductively coupled (argon) plasma optical emission spectroscopy (ICPOES) (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 antimony, arsenic, beryllium, cadmium, cesium, cobalt, copper, lead, lithium, mercury, molybdenum, nickel, rubidium, selenium, silver, thallium, thorium, tin, vanadium, uranium, and zinc were analyzed by inductively coupled (argon) plasma mass spectrometry (ICPMS) (EPA Method 200.8, Revision 5.4).

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/or the presence of drilling fluids.

Charge balance errors for total cations and anions for the samples ranged from –6% to –14%. The negative cation-anion charge balance values indicate excess anions for the filtered samples. The precision limits (analytical error) for major ions and trace elements were generally less than ±7%.

B-1.1.2 Off-site Laboratory Analytical Techniques

GEL Laboratories, LLC, analyzed aliquots of the two unfiltered borehole groundwater samples (for VOCs, HE and metals) as well as one of the well development samples (for TOC) using the following EPA analytical methods:

- VOCs by SW846:8260B
- HE by SW846:8321A_MOD

- Metals by SW-846:6010B (ICPOES), SW-846:6020 (ICPMS), or SW-846:7470A
- TOC by EPA:415.1

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 multimeter. Results of field parameters, consisting of pH, temperature, dissolved oxygen (DO), oxidation-reduction potential (ORP), specific conductance, and turbidity are provided in Table B-1.2-1.

During development, pH and temperature varied from 6.71 to 9.68 and from 9.11°C to 19.29°C, respectively. The regional aquifer has background pH values ranging from 6.43 to 8.96 with a median value of 7.85 (LANL 2007, 095817). Elevated pH readings likely resulted from the improper use of the pH probe. Concentrations of DO ranged from 2.98 to 8.78 mg/L. Specific conductance varied from 134 to 347 microsiemens per centimeter (μS/cm), and turbidity varied from 3008 nephelometric turbidity units (NTU) at the beginning to 4.78 NTU near the end of development (Table B-1.2-1). The final turbidity reading at the end of development was 4.98 NTUs.

Corrected Eh values determined from field ORP measurements ranged from 48.8 to 220.5 millivolts (mV) during development. The correction factor applied to the ORP field measurements was 208.9 mV, calculated from an Ag/AgCl-saturated KCl electrode filling solution at 15°C. With one exception, all the noncorrected ORP values recorded during development were negative, which resulted in lower overall corrected Eh values. Corrected Eh values associated with well R-29 are considered to be generally reliable and representative of the known relatively oxidizing conditions characteristic of the regional aquifer beneath the Pajarito Plateau.

B-1.2.2 Aquifer Testing

During aquifer testing, pH and temperature varied from 5.09 to 11.24 and from 13.82°C to 17.85°C, respectively. The pH values measured during aquifer testing consistently exceeded the pH concentrations measured during well development; 27 of 49 pH measurements exceeded the regional aquifer background maximum value of 8.96. Therefore, it is likely that the meter was again being operated incorrectly during much of the aquifer testing. Concentrations of DO varied from 1.91 to 5.67 mg/L. Corrected Eh values determined from field ORP measurements varied from 55.1 to 207.8 mV. Specific conductance varied from 146 to 167 μS/cm, and turbidity values varied from 103.2 to 0.69 NTU, with a final value of 4.27 NTU.

B-1.3 Analytical Results

Analytical results from GEL Laboratories and the EES-14 laboratory are presented in Tables B-1.3-1 and B-1.3-2, respectively, and are discussed below. Some analytical results for well R-29 are screened against background regional aquifer concentrations from completed wells that apply to 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-29 may vary from the sitewide background concentrations.

B-1.3.1 Volatile Organic Compounds and High Explosive Compounds

Two samples, GW29-10-13276 and GW29-10-13277, were collected during drilling and analyzed for VOCs and HE compounds (Table B-1.3-1). No VOCs or HE compounds were detected in either of the borehole screening samples.

B-1.3.2 Cations, Anions, Perchlorate and Metals

EES-14 analytical results for cations, anions, perchlorate, and metals from two borehole samples collected during drilling (GW29-10-13276 and GW29-10-13277) and for one sample collected at the end of well development (GW29-10-13270) are provided in Table B-1.3-2. The results for metal analyses conducted by GEL Laboratories on the two borehole samples are included in Table B-1.3.1.

The filtered borehole samples for GW29-10-13276 and GW29-10-13277 that were analyzed by EES-14 consisted of colloidal aquifer material, drilling material, water used during drilling, and native groundwater. The borehole water samples analyzed by GEL Laboratories were not filtered.

Dissolved concentrations of fluoride were 0.37 and 0.25 ppm in the two borehole water samples collected during drilling of R-29. During development of well R-29, the dissolved concentration of fluoride was 0.22 ppm, below the median fluoride concentration from completed wells in the regional aquifer of 0.35 ppm. Dissolved nitrate(N) concentrations were 0.35 and 0.43 ppm in the two borehole water samples collected during drilling of R-29. Dissolved sulfate concentrations were 3.97 and 2.84 ppm in the same borehole water samples. Dissolved nitrate(N) and sulfate concentrations were 0.44 and 9.84 ppm, respectively, during development at well R-29. Median background concentrations for dissolved nitrate(N) and sulfate in the regional aquifer are 0.31 mg/L and 2.83 mg/L, respectively (LANL 2007, 095817). Perchlorate was not detected in the two borehole water samples or in the one sample from well development at well R-29.

The following metal results are from the two borehole samples and the one well development sample submitted to EES-14 for metals analyses (GW29-10-13270) (Table B-1.3-2).

- The dissolved molybdenum concentration for GW29-10-13277 from 1175,0 ft bgs was 0.012 ppm, which is slightly elevated relative to the regional aquifer maximum background concentration of 0.0044 ppm, suggesting this sample may contain a component of lubricant used during drilling. In contrast, the groundwater sample GW29-10-13270 collected during well development from 1175.0 ft bgs in the completed well contained 0.002 ppm of dissolved molybdenum.
- Dissolved concentrations of iron, manganese, and zinc were 0.31, 0.045, and 0.041 ppm, respectively, in the sample collected during well development. Maximum regional aquifer background concentrations for these three metals are 0.147, 0.124, and 0.032 ppm, respectively. A corroded carbon-steel discharge pipe was used during well development at R-29, which likely resulted in the slightly elevated concentrations of colloidal iron, manganese, and zinc.
- Dissolved concentrations of boron were 0.244 and 0.070 ppm in the two borehole water samples. The dissolved concentration of boron from the well development sample was 0.058 ppm. Maximum background concentration for dissolved boron in the regional aquifer is 0.0516 ppm (LANL 2007, 095817).
- Dissolved concentrations of barium were 0.869 and 0.454 ppm in the two borehole water samples collected during drilling of R-29. The dissolved concentration of barium was 0.208 ppm in GW29-10-13270 collected during development. Maximum background concentration for dissolved barium in the regional aquifer is 0.115 ppm (LANL 2007, 095817).
- Total dissolved concentrations of chromium were 0.007 and 0.003 ppm in the two borehole water samples. The dissolved concentration of chromium from the sample collected during well development was 0.004 ppm. Background mean, median, and maximum concentrations of total dissolved chromium are 0.0031, 0.0031, and 0.0072 ppm, respectively, for developed wells in the regional aquifer (LANL 2007, 095817).

Analytical results for 23 metals from GEL Laboratories for the two unfiltered borehole samples (Table B-1.3-1) were consistently higher in concentration that the EES-14 analytical results for the same metals. The difference in results is because the samples analyzed by GEL Laboratories were not filtered.

B-1.3.3 Total Organic Carbon

The TOC concentrations for the three samples collected during well development are: undetected (1 mgC/L) for the sample submitted to GEL Laboratories, and 0.25 and 0.30 mgC/L for the two samples analyzed by EES-14. All results were below the target concentration of 2.0 mgC/L. The median background concentration of TOC is 0.34 mgC/L for regional aquifer groundwater (LANL 2007, 095817).

B-1.4 Summary

In summary, regional aquifer groundwater at well R-29 is relatively oxidizing based on corrected, positive Eh values. Redox conditions based on corrected field ORP measurements at well R-29 are similar to other previously drilled wells on the Pajarito Plateau. Elevated molybdenum from one borehole sample is likely associated with drilling lubricant; the molybdenum concentration from the developed well was within the range of Laboratory background concentrations. No VOCs or HE compounds were detected at R-29. Concentrations of TOC were less than the target value of 2.0 mgC/L in the three well development samples.

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 Water Quality Parameters during Development at Well R-29

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									
03/16/10 (Bailing)	1430	n/r[b]	n/r	n/r	n/r	n/r	n/r	0	0
	1800	n/r	n/r	n/r	n/r	n/r	n/r	56	56
03/17/10 (Bailing)	1300	n/r	n/r	n/r	n/r	n/r	n/r	78	134
03/18/10 (Pump)	1032	7.37	17.33	7.47	16.6, 220.5	347	3008.0	5	139
	1132	6.71	15.40	7.27	-134.8, 74.1	213	1479.0	196	335
	1232	9.68	18.26	4.60	-88.9, 115.0	207	164.0	259	594
	1332	7.90	18.80	8.78	-58.9, 145.0	191	97.8	304	899
	1432	8.00	18.48	7.64	-59.3, 144.6	179	48.8	310	1208
	1532	8.09	18.58	7.11	-93.0, 110.9	168	30.4	298	1507
	1632	8.02	17.89	5.84	-97.2, 106.7	162	26.5	343	1849
	1732	7.95	17.32	5.22	-69.1, 139.8	157	22.9	331	2180
	1800	7.99	17.29	5.31	-70.2, 138.7	156	21.1	120	2300
03/19/10 (Pump)	0800	8.09	19.29	5.16	-160.1, 48.8	169	69.1	2	2303
	0900	7.55	15.03	8.35	-139.6, 69.3	170	36.2	364	2667
	1000	7.69	16.47	6.71	-145.5, 63.4	159	34.9	327	2994
	1106	7.96	17.94	4.62	-86.8, 117.1	155	20.6	389	3383
	1200	7.81	17.10	4.94	-90.3, 118.6	150	9.76	287	3670
	1300	7.68	16.80	4.92	-73.1, 135.8	147	13.3	343	4013
	1430[c]	7.98	14.75	4.26	-54.1, 154.8	147	14.4	507	4520
	1530	6.72	15.27	4.50	-87.3, 121.6	146	13.1	338	4858
	1630	7.39	15.74	4.55	-71.1, 137.8	144	10.92	342	5200
	1730	8.31	15.69	3.61	-53.8, 155.1	143	7.70	336	5536
	1830	8.01	15.22	3.75	-60.1, 148.8	141	7.91	334	5870
	1900	7.79	15.32	3.78	-67.5, 141.4	143	8.00	161	6031
03/20/10 (Pump)	0730	7.82	9.11	4.23	-127, 86.0	141	61.10	4	6035
	0830	7.93	14.89	6.61	-106.0, 102,9	146	11.90	340	6375
	0930	8.81	14.35	5.08	-134.7, 74.2	144	8.62	346	6721
	1030	8.57	15.93	3.97	-122.3, 86.6	141	6.85	339	7060
	1130	8.97	15.96	3.46	-111.4, 97.5	139	6.48	343	7403
	1230	8.98	16.04	3.06	-89.9, 119.0	139	5.92	343	7746
	1330	9.01	16.03	2.98	-90.2, 118.7	138	5.22	340	8085
	1430	7.48	15.51	4.81	-96.1, 112.8	137	4.78	333	8418
	1530	6.99	16.34	4.85	-102.1, 106.8	137	5.54	348	8766
	1630	7.49	15.47	3.90	-131.4, 77.5	134	4.78	328	9093
	1730	6.98	16.59	3.12	-87.5,121.4	135	5.05	328	9422
	1830	6.71	16.26	3.11	-81.3, 127.6	135	4.98	335	9757
03/21/10 (Pump)	1530	n/r	n/r	n/r	n/r	n/r	n/r	119	9875

Table B-1.2-1 (continued)

Date	Time	pH	Temp (°C)	DO (mg/L)	ORP, Eh (mV)	Specific Conductivity (µS/cm)	Turbidity (NTU)	Purge Volume between Samples (gal.)	Cumulative Purge Volume (gal.)
Aquifer Testing									
03/22/10 (Step Tests)	1052	5.09	14.24	2.02	-110.8, 98.1	149	103.2	n/r	9875
	1100	n/r	n/r	n/r	n/r	n/r	n/r	120.98	9996
	1201	9.15	17.37	3.72	11.0, 123.0	161	30.4	n/r	9996
	1231	9.93	17.07	3.61	-1.1, 207.8	167	16.3	n/r	9996
	1251	10.14	17.85	3.02	-19.7, 184.2	164	9.24	n/r	9996
	1300	n/r	n/r	n/r	n/r	n/r	n/r	243.41	10240
03/24/10 (24-H Pumping Test)	0801	n/r	n/r	n/r	n/r	n/r	n/r	0	10240
	0900	11.24	15.96	2.05	-153.8, 55.1	163	4.71	124	12336
	1000	10.45	16.36	5.04	-117.4, 91.5	161	4.22	123	12459
	1100	9.40	17.08	5.17	-78.2, 130.7	155	3.88	124	12583
	1130	8.66	17.53	5.40	-80.9, 123.0	158	3.42	123	12706
	1204	9.69	17.41	5.67	-81.7, 127.2	157	2.44	123	12829
	1230	10.23	17.32	5.38	-76.6, 132.3	155	3.34	124	12953
	1300	8.80	17.67	5.33	-71.5, 132.4	156	3.35	124	13077
	1330	8.48	17.49	5.28	-64.6, 144.3	155	3.68	124	13201
	1400	8.22	17.55	5.18	-65.4, 138.5	154	4.05	124	13325
	1430	8.36	17.49	4.69	-65.9, 143.0	153	3.91	124	13449
	1500	8.42	17.42	3.76	-65.7, 143.2	155	3.54	124	13573
	1530	8.19	17.41	3.90	-65.1, 143.8	152	4.00	124	13696
	1600	7.92	17.36	3.93	-69.5, 139.4	152	4.60	124	13820
	1630	7.59	17.37	3.97	-60.4, 148.5	153	3.43	123	13943
	1700	7.48	17.45	4.12	-53.8, 155.1	153	3.43	128	14071
	1730	7.71	17.31	3.44	-71.1, 137.8	153	3.66	103	14174
	1800	7.60	17.25	4.04	-53.0, 155.9	153	3.25	124	12336
	1830	7.46	17.32	4.61	-52.3, 156.6	154	3.75	123	12459
	1900	7.57	17.03	4.40	-54.1, 154.8	154	3.68	124	12583
	1930	7.76	16.17	3.99	-63.1, 145.8	152	4.01	123	12706
	2000	8.68	15.95	3.94	-67.9, 141.0	151	4.09	123	12829
	2030	8.36	16.30	3.76	-94.0, 114.9	150	2.68	124	12953
	2100	8.83	15.64	3.83	-95.5, 113.4	153	4.20	124	13077
	2130	8.98	15.60	3.61	-99.8, 109.1	153	3.07	124	13201
	2200	9.29	15.44	3.57	-80.0, 128.9	152	2.65	124	13325
	2230	8.68	15.76	3.31	-89.5, 119.4	152	2.51	124	13449
	2300	8.38	15.79	3.16	-84.3,124.6	157	3.95	124	13573
	2333	8.70	15.78	3.05	-84.5, 124.4	153	3.01	124	13696
	2400	8.42	16.28	2.93	-83.1, 125.8	149	1.95	124	13820

Table B-1.2-1 (continued)

Date	Time	pH	Temp (°C)	DO (mg/L)	ORP, Eh (mV)	Specific Conductivity (µS/cm)	Turbidity (NTU)	Purge Volume between Samples (gal.)	Cumulative Purge Volume (gal.)
Aquifer Testing									
03/25/10 (24-H Pumping Test)	0030	9.19	15.77	2.91	-77.2, 126.7	152	2.16	104	14278
	0100	9.11	16.20	2.70	-76.4, 132.5	152	1.86	92	14370
	0130	9.00	16.36	2.59	-77.3, 131.6	150	1.60	106	14475
	0200	9.05	16.28	2.43	-76.3, 132.6	151	1.10	92	14568
	0230	9.08	16.07	2.39	-78.5, 130.4	151	0.97	92	14660
	0300	9.18	15.77	2.29	-77.0, 131.9	152	1.26	64	14724
	0330	9.05	14.79	3.38	-74.5, 134.4	149	0.69	70	14794
	0400	9.47	15.24	2.24	-76.8, 132.1	150	1.59	65	14859
	0430	9.45	16.09	2.10	-74.3, 134.6	150	1.14	63	14923
	0500	9.32	16.50	2.03	-74.3, 134.6	152	1.14	60	14983
	0530	9.48	15.86	2.09	-74.3, 134.6	150	2.09	40	15023
	0600	9.47	15.34	2.07	-76.4, 132.5	148	1.37	29	15052
	0630	9.38	14.90	1.93	-77.0, 131.9	148	1.77	27	15078
	0700	9.34	14.28	1.91	-73.7, 135.2	146	2.73	23	15101
	0730	9.45	14.17	1.91	-77.5, 131.4	147	4.27	20	15121
	0800	9.42	13.82	1.93	-69.6, 139.3	147	n/r	15	15136

[a] Eh (mV) is calculated from a Ag/AgCl saturated KCl electrode filling solution at 10ºC, 15ºC, and 20ºC by adding a temperature-sensitive correction factors of 213.8 mV, 208.9 mV, and 203.9 mV, respectively.

[b] n/r = Not recorded.

[c] 1430 = Lightning delay.

Table B-1.3-1
Off-site Laboratory Analytical Data

Lab Request Number	Sample ID	Analytical Suite Code	Analytical Method	Analyte Description	Lab Result	Unit	Validation Qualifier Code
10-2534	GW29-10-13271	TOC	EPA:415.1	TOC	1	ug/L	U[a]
10-2185	GW29-10-13275	VOC	SW-846:8260B	Acetone	10	ug/L	U
10-2185	GW29-10-13275	VOC	SW-846:8260B	Acetonitrile	25	ug/L	R[b]
10-2185	GW29-10-13275	VOC	SW-846:8260B	Acrolein	5	ug/L	U
10-2185	GW29-10-13275	VOC	SW-846:8260B	Acrylonitrile	5	ug/L	U
10-2185	GW29-10-13275	VOC	SW-846:8260B	Benzene	1	ug/L	U
10-2185	GW29-10-13275	VOC	SW-846:8260B	Bromobenzene	1	ug/L	U
10-2185	GW29-10-13275	VOC	SW-846:8260B	Bromochloromethane	1	ug/L	U
10-2185	GW29-10-13275	VOC	SW-846:8260B	Bromodichloromethane	1	ug/L	U
10-2185	GW29-10-13275	VOC	SW-846:8260B	Bromoform	1	ug/L	U
10-2185	GW29-10-13275	VOC	SW-846:8260B	Bromomethane	1	ug/L	U
10-2185	GW29-10-13275	VOC	SW-846:8260B	Butanol[1-]	50	ug/L	R
10-2185	GW29-10-13275	VOC	SW-846:8260B	Butanone[2-]	5	ug/L	U
10-2185	GW29-10-13275	VOC	SW-846:8260B	Butylbenzene[n-]	1	ug/L	U
10-2185	GW29-10-13275	VOC	SW-846:8260B	Butylbenzene[sec-]	1	ug/L	U
10-2185	GW29-10-13275	VOC	SW-846:8260B	Butylbenzene[tert-]	1	ug/L	U
10-2185	GW29-10-13275	VOC	SW-846:8260B	Carbon Disulfide	5	ug/L	U
10-2185	GW29-10-13275	VOC	SW-846:8260B	Carbon Tetrachloride	1	ug/L	U
10-2185	GW29-10-13275	VOC	SW-846:8260B	Chloro-1,3-butadiene[2-]	1	ug/L	UJ[c]
10-2185	GW29-10-13275	VOC	SW-846:8260B	Chloro-1-propene[3-]	5	ug/L	U
10-2185	GW29-10-13275	VOC	SW-846:8260B	Chlorobenzene	1	ug/L	U
10-2185	GW29-10-13275	VOC	SW-846:8260B	Chlorodibromomethane	1	ug/L	U
10-2185	GW29-10-13275	VOC	SW-846:8260B	Chloroethane	1	ug/L	U
10-2185	GW29-10-13275	VOC	SW-846:8260B	Chloroform	1	ug/L	U
10-2185	GW29-10-13275	VOC	SW-846:8260B	Chloromethane	1	ug/L	U
10-2185	GW29-10-13275	VOC	SW-846:8260B	Chlorotoluene[2-]	1	ug/L	U
10-2185	GW29-10-13275	VOC	SW-846:8260B	Chlorotoluene[4-]	1	ug/L	U
10-2185	GW29-10-13275	VOC	SW-846:8260B	Dibromo-3-Chloropropane[1,2-]	1	ug/L	U
10-2185	GW29-10-13275	VOC	SW-846:8260B	Dibromoethane[1,2-]	1	ug/L	U
10-2185	GW29-10-13275	VOC	SW-846:8260B	Dibromomethane	1	ug/L	U
10-2185	GW29-10-13275	VOC	SW-846:8260B	Dichlorobenzene[1,2-]	1	ug/L	U
10-2185	GW29-10-13275	VOC	SW-846:8260B	Dichlorobenzene[1,3-]	1	ug/L	U
10-2185	GW29-10-13275	VOC	SW-846:8260B	Dichlorobenzene[1,4-]	1	ug/L	U
10-2185	GW29-10-13275	VOC	SW-846:8260B	Dichlorodifluoromethane	1	ug/L	U
10-2185	GW29-10-13275	VOC	SW-846:8260B	Dichloroethane[1,1-]	1	ug/L	U
10-2185	GW29-10-13275	VOC	SW-846:8260B	Dichloroethane[1,2-]	1	ug/L	U
10-2185	GW29-10-13275	VOC	SW-846:8260B	Dichloroethene[1,1-]	1	ug/L	U

Table B-1.3-1 (continued)

Lab Request Number	Sample ID	Analytical Suite Code	Analytical Method	Analyte Description	Lab Result	Unit	Validation Qualifier Code
10-2185	GW29-10-13275	VOC	SW-846:8260B	Dichloroethene[cis-1,2-]	1	ug/L	U
10-2185	GW29-10-13275	VOC	SW-846:8260B	Dichloroethene[trans-1,2-]	1	ug/L	U
10-2185	GW29-10-13275	VOC	SW-846:8260B	Dichloropropane[1,2-]	1	ug/L	U
10-2185	GW29-10-13275	VOC	SW-846:8260B	Dichloropropane[1,3-]	1	ug/L	U
10-2185	GW29-10-13275	VOC	SW-846:8260B	Dichloropropane[2,2-]	1	ug/L	U
10-2185	GW29-10-13275	VOC	SW-846:8260B	Dichloropropene[1,1-]	1	ug/L	U
10-2185	GW29-10-13275	VOC	SW-846:8260B	Dichloropropene[cis-1,3-]	1	ug/L	U
10-2185	GW29-10-13275	VOC	SW-846:8260B	Dichloropropene[trans-1,3-]	1	ug/L	U
10-2185	GW29-10-13275	VOC	SW-846:8260B	Diethyl Ether	1	ug/L	U
10-2185	GW29-10-13275	VOC	SW-846:8260B	Ethyl Methacrylate	5	ug/L	U
10-2185	GW29-10-13275	VOC	SW-846:8260B	Ethylbenzene	1	ug/L	U
10-2185	GW29-10-13275	VOC	SW-846:8260B	Hexachlorobutadiene	1	ug/L	U
10-2185	GW29-10-13275	VOC	SW-846:8260B	Hexanone[2-]	5	ug/L	U
10-2185	GW29-10-13275	VOC	SW-846:8260B	Iodomethane	5	ug/L	U
10-2185	GW29-10-13275	VOC	SW-846:8260B	Isobutyl alcohol	50	ug/L	R
10-2185	GW29-10-13275	VOC	SW-846:8260B	Isopropylbenzene	1	ug/L	U
10-2185	GW29-10-13275	VOC	SW-846:8260B	Isopropyltoluene[4-]	1	ug/L	U
10-2185	GW29-10-13275	VOC	SW-846:8260B	Methacrylonitrile	5	ug/L	U
10-2185	GW29-10-13275	VOC	SW-846:8260B	Methyl Methacrylate	5	ug/L	U
10-2185	GW29-10-13275	VOC	SW-846:8260B	Methyl tert-Butyl Ether	1	ug/L	U
10-2185	GW29-10-13275	VOC	SW-846:8260B	Methyl-2-pentanone[4-]	5	ug/L	U
10-2185	GW29-10-13275	VOC	SW-846:8260B	Methylene Chloride	10	ug/L	U
10-2185	GW29-10-13275	VOC	SW-846:8260B	Naphthalene	1	ug/L	U
10-2185	GW29-10-13275	VOC	SW-846:8260B	Propionitrile	5	ug/L	U
10-2185	GW29-10-13275	VOC	SW-846:8260B	Propylbenzene[1-]	1	ug/L	U
10-2185	GW29-10-13275	VOC	SW-846:8260B	Styrene	1	ug/L	U
10-2185	GW29-10-13275	VOC	SW-846:8260B	Tetrachloroethane[1,1,1,2-]	1	ug/L	U
10-2185	GW29-10-13275	VOC	SW-846:8260B	Tetrachloroethane[1,1,2,2-]	1	ug/L	U
10-2185	GW29-10-13275	VOC	SW-846:8260B	Tetrachloroethene	1	ug/L	U
10-2185	GW29-10-13275	VOC	SW-846:8260B	Toluene	1	ug/L	U
10-2185	GW29-10-13275	VOC	SW-846:8260B	Trichloro-1,2,2-trifluoroethane[1,1,2-]	5	ug/L	U
10-2185	GW29-10-13275	VOC	SW-846:8260B	Trichlorobenzene[1,2,3-]	1	ug/L	U
10-2185	GW29-10-13275	VOC	SW-846:8260B	Trichlorobenzene[1,2,4-]	1	ug/L	U
10-2185	GW29-10-13275	VOC	SW-846:8260B	Trichloroethane[1,1,1-]	1	ug/L	U
10-2185	GW29-10-13275	VOC	SW-846:8260B	Trichloroethane[1,1,2-]	1	ug/L	U
10-2185	GW29-10-13275	VOC	SW-846:8260B	Trichloroethene	1	ug/L	U
10-2185	GW29-10-13275	VOC	SW-846:8260B	Trichlorofluoromethane	1	ug/L	U

Table B-1.3-1 (continued)

Lab Request Number	Sample ID	Analytical Suite Code	Analytical Method	Analyte Description	Lab Result	Unit	Validation Qualifier Code
10-2185	GW29-10-13275	VOC	SW-846:8260B	Trichloropropane[1,2,3-]	1	ug/L	U
10-2185	GW29-10-13275	VOC	SW-846:8260B	Trimethylbenzene[1,2,4-]	1	ug/L	U
10-2185	GW29-10-13275	VOC	SW-846:8260B	Trimethylbenzene[1,3,5-]	1	ug/L	U
10-2185	GW29-10-13275	VOC	SW-846:8260B	Vinyl acetate	5	ug/L	UJ
10-2185	GW29-10-13275	VOC	SW-846:8260B	Vinyl Chloride	1	ug/L	U
10-2185	GW29-10-13275	VOC	SW-846:8260B	Xylene[1,2-]	1	ug/L	U
10-2185	GW29-10-13275	VOC	SW-846:8260B	Xylene[1,3-]+Xylene[1,4-]	2	ug/L	U
10-2185	GW29-10-13276	HE	SW-846:8321A_MOD	2,4-Diamino-6-nitrotoluene	1.3	ug/L	U
10-2185	GW29-10-13276	HE	SW-846:8321A_MOD	2,6-Diamino-4-nitrotoluene	1.3	ug/L	UJ
10-2185	GW29-10-13276	HE	SW-846:8321A_MOD	3,5-Dinitroaniline	1.3	ug/L	U
10-2185	GW29-10-13276	HE	SW-846:8321A_MOD	Amino-2,6-dinitrotoluene[4-]	0.325	ug/L	UJ
10-2185	GW29-10-13276	HE	SW-846:8321A_MOD	Amino-4,6-dinitrotoluene[2-]	0.325	ug/L	UJ
10-2185	GW29-10-13276	HE	SW-846:8321A_MOD	Dinitrobenzene[1,3-]	0.325	ug/L	UJ
10-2185	GW29-10-13276	HE	SW-846:8321A_MOD	Dinitrotoluene[2,4-]	0.325	ug/L	UJ
10-2185	GW29-10-13276	HE	SW-846:8321A_MOD	Dinitrotoluene[2,6-]	0.325	ug/L	UJ
10-2185	GW29-10-13276	HE	SW-846:8321A_MOD	HMX[d]	0.325	ug/L	UJ
10-2185	GW29-10-13276	HE	SW-846:8321A_MOD	Nitrobenzene	0.325	ug/L	UJ
10-2185	GW29-10-13276	HE	SW-846:8321A_MOD	Nitrotoluene[2-]	0.325	ug/L	UJ
10-2185	GW29-10-13276	HE	SW-846:8321A_MOD	Nitrotoluene[3-]	0.325	ug/L	UJ
10-2185	GW29-10-13276	HE	SW-846:8321A_MOD	Nitrotoluene[4-]	0.649	ug/L	UJ
10-2185	GW29-10-13276	HE	SW-846:8321A_MOD	PETN[e]	1.3	ug/L	UJ
10-2185	GW29-10-13276	HE	SW-846:8321A_MOD	RDX[f]	0.325	ug/L	UJ
10-2185	GW29-10-13276	HE	SW-846:8321A_MOD	TATB[g]	1.3	ug/L	U
10-2185	GW29-10-13276	HE	SW-846:8321A_MOD	Tetryl	0.649	ug/L	UJ
10-2185	GW29-10-13276	HE	SW-846:8321A_MOD	Trinitrobenzene[1,3,5-]	0.325	ug/L	UJ
10-2185	GW29-10-13276	HE	SW-846:8321A_MOD	Trinitrotoluene[2,4,6-]	0.325	ug/L	UJ
10-2185	GW29-10-13276	HE	SW-846:8321A_MOD	Tris (o-cresyl) phosphate	1.3	ug/L	U
10-2185	GW29-10-13276	METALS	SW-846:6010B	Aluminum	25400	ug/L	NQ[h]
10-2185	GW29-10-13276	METALS	SW-846:6020	Antimony	3	ug/L	U
10-2185	GW29-10-13276	METALS	SW-846:6010B	Arsenic	5.59	ug/L	J[i]
10-2185	GW29-10-13276	METALS	SW-846:6010B	Barium	249	ug/L	NQ
10-2185	GW29-10-13276	METALS	SW-846:6020	Beryllium	0.734	ug/L	NQ
10-2185	GW29-10-13276	METALS	SW-846:6020	Cadmium	0.342	ug/L	J
10-2185	GW29-10-13276	METALS	SW-846:6010B	Calcium	17900	ug/L	J+[j]
10-2185	GW29-10-13276	METALS	SW-846:6010B	Chromium	37.8	ug/L	NQ
10-2185	GW29-10-13276	METALS	SW-846:6010B	Cobalt	39.7	ug/L	NQ
10-2185	GW29-10-13276	METALS	SW-846:6010B	Copper	30.8	ug/L	NQ
10-2185	GW29-10-13276	METALS	SW-846:6010B	Iron	25500	ug/L	NQ

Table B-1.3-1 (continued)

Lab Request Number	Sample ID	Analytical Suite Code	Analytical Method	Analyte Description	Lab Result	Unit	Validation Qualifier Code
10-2185	GW29-10-13276	METALS	SW-846:6020	Lead	9.08	ug/L	NQ
10-2185	GW29-10-13276	METALS	SW-846:6010B	Magnesium	6000	ug/L	NQ
10-2185	GW29-10-13276	METALS	SW-846:6020	Manganese	443	ug/L	NQ
10-2185	GW29-10-13276	METALS	SW-846:7470A	Mercury	0.2	ug/L	U
10-2185	GW29-10-13276	METALS	SW-846:6010B	Nickel	19.5	ug/L	NQ
10-2185	GW29-10-13276	METALS	SW-846:6010B	Potassium	4210	ug/L	NQ
10-2185	GW29-10-13276	METALS	SW-846:6010B	Selenium	30	ug/L	U
10-2185	GW29-10-13276	METALS	SW-846:6010B	Silver	1.17	ug/L	J
10-2185	GW29-10-13276	METALS	SW-846:6010B	Sodium	14800	ug/L	J+
10-2185	GW29-10-13276	METALS	SW-846:6020	Thallium	1.01	ug/L	U
10-2185	GW29-10-13276	METALS	SW-846:6010B	Vanadium	25.8	ug/L	NQ
10-2185	GW29-10-13276	METALS	SW-846:6010B	Zinc	240	ug/L	NQ
10-2185	GW29-10-13276	VOC	SW-846:8260B	Acetone	10	ug/L	U
10-2185	GW29-10-13276	VOC	SW-846:8260B	Acetonitrile	25	ug/L	R
10-2185	GW29-10-13276	VOC	SW-846:8260B	Acrolein	5	ug/L	U
10-2185	GW29-10-13276	VOC	SW-846:8260B	Acrylonitrile	5	ug/L	U
10-2185	GW29-10-13276	VOC	SW-846:8260B	Benzene	1	ug/L	U
10-2185	GW29-10-13276	VOC	SW-846:8260B	Bromobenzene	1	ug/L	U
10-2185	GW29-10-13276	VOC	SW-846:8260B	Bromochloromethane	1	ug/L	U
10-2185	GW29-10-13276	VOC	SW-846:8260B	Bromodichloromethane	1	ug/L	U
10-2185	GW29-10-13276	VOC	SW-846:8260B	Bromoform	1	ug/L	U
10-2185	GW29-10-13276	VOC	SW-846:8260B	Bromomethane	1	ug/L	U
10-2185	GW29-10-13276	VOC	SW-846:8260B	Butanol[1-]	50	ug/L	R
10-2185	GW29-10-13276	VOC	SW-846:8260B	Butanone[2-]	5	ug/L	U
10-2185	GW29-10-13276	VOC	SW-846:8260B	Butylbenzene[n-]	1	ug/L	U
10-2185	GW29-10-13276	VOC	SW-846:8260B	Butylbenzene[sec-]	1	ug/L	U
10-2185	GW29-10-13276	VOC	SW-846:8260B	Butylbenzene[tert-]	1	ug/L	U
10-2185	GW29-10-13276	VOC	SW-846:8260B	Carbon Disulfide	5	ug/L	U
10-2185	GW29-10-13276	VOC	SW-846:8260B	Carbon Tetrachloride	1	ug/L	U
10-2185	GW29-10-13276	VOC	SW-846:8260B	Chloro-1,3-butadiene[2-]	1	ug/L	UJ
10-2185	GW29-10-13276	VOC	SW-846:8260B	Chloro-1-propene[3-]	5	ug/L	U
10-2185	GW29-10-13276	VOC	SW-846:8260B	Chlorobenzene	1	ug/L	U
10-2185	GW29-10-13276	VOC	SW-846:8260B	Chlorodibromomethane	1	ug/L	U
10-2185	GW29-10-13276	VOC	SW-846:8260B	Chloroethane	1	ug/L	U
10-2185	GW29-10-13276	VOC	SW-846:8260B	Chloroform	1	ug/L	U
10-2185	GW29-10-13276	VOC	SW-846:8260B	Chloromethane	1	ug/L	U
10-2185	GW29-10-13276	VOC	SW-846:8260B	Chlorotoluene[2-]	1	ug/L	U
10-2185	GW29-10-13276	VOC	SW-846:8260B	Chlorotoluene[4-]	1	ug/L	U

Table B-1.3-1 (continued)

Lab Request Number	Sample ID	Analytical Suite Code	Analytical Method	Analyte Description	Lab Result	Unit	Validation Qualifier Code
10-2185	GW29-10-13276	VOC	SW-846:8260B	Dibromo-3-Chloropropane[1,2-]	1	ug/L	U
10-2185	GW29-10-13276	VOC	SW-846:8260B	Dibromoethane[1,2-]	1	ug/L	U
10-2185	GW29-10-13276	VOC	SW-846:8260B	Dibromomethane	1	ug/L	U
10-2185	GW29-10-13276	VOC	SW-846:8260B	Dichlorobenzene[1,2-]	1	ug/L	U
10-2185	GW29-10-13276	VOC	SW-846:8260B	Dichlorobenzene[1,3-]	1	ug/L	U
10-2185	GW29-10-13276	VOC	SW-846:8260B	Dichlorobenzene[1,4-]	1	ug/L	U
10-2185	GW29-10-13276	VOC	SW-846:8260B	Dichlorodifluoromethane	1	ug/L	U
10-2185	GW29-10-13276	VOC	SW-846:8260B	Dichloroethane[1,1-]	1	ug/L	U
10-2185	GW29-10-13276	VOC	SW-846:8260B	Dichloroethane[1,2-]	1	ug/L	U
10-2185	GW29-10-13276	VOC	SW-846:8260B	Dichloroethene[1,1-]	1	ug/L	U
10-2185	GW29-10-13276	VOC	SW-846:8260B	Dichloroethene[cis-1,2-]	1	ug/L	U
10-2185	GW29-10-13276	VOC	SW-846:8260B	Dichloroethene[trans-1,2-]	1	ug/L	U
10-2185	GW29-10-13276	VOC	SW-846:8260B	Dichloropropane[1,2-]	1	ug/L	U
10-2185	GW29-10-13276	VOC	SW-846:8260B	Dichloropropane[1,3-]	1	ug/L	U
10-2185	GW29-10-13276	VOC	SW-846:8260B	Dichloropropane[2,2-]	1	ug/L	U
10-2185	GW29-10-13276	VOC	SW-846:8260B	Dichloropropene[1,1-]	1	ug/L	U
10-2185	GW29-10-13276	VOC	SW-846:8260B	Dichloropropene[cis-1,3-]	1	ug/L	U
10-2185	GW29-10-13276	VOC	SW-846:8260B	Dichloropropene[trans-1,3-]	1	ug/L	U
10-2185	GW29-10-13276	VOC	SW-846:8260B	Diethyl Ether	1	ug/L	U
10-2185	GW29-10-13276	VOC	SW-846:8260B	Ethyl Methacrylate	5	ug/L	U
10-2185	GW29-10-13276	VOC	SW-846:8260B	Ethylbenzene	1	ug/L	U
10-2185	GW29-10-13276	VOC	SW-846:8260B	Hexachlorobutadiene	1	ug/L	U
10-2185	GW29-10-13276	VOC	SW-846:8260B	Hexanone[2-]	5	ug/L	U
10-2185	GW29-10-13276	VOC	SW-846:8260B	Iodomethane	5	ug/L	U
10-2185	GW29-10-13276	VOC	SW-846:8260B	Isobutyl alcohol	50	ug/L	R
10-2185	GW29-10-13276	VOC	SW-846:8260B	Isopropylbenzene	1	ug/L	U
10-2185	GW29-10-13276	VOC	SW-846:8260B	Isopropyltoluene[4-]	1	ug/L	U
10-2185	GW29-10-13276	VOC	SW-846:8260B	Methacrylonitrile	5	ug/L	U
10-2185	GW29-10-13276	VOC	SW-846:8260B	Methyl Methacrylate	5	ug/L	U
10-2185	GW29-10-13276	VOC	SW-846:8260B	Methyl tert-Butyl Ether	1	ug/L	U
10-2185	GW29-10-13276	VOC	SW-846:8260B	Methyl-2-pentanone[4-]	5	ug/L	U
10-2185	GW29-10-13276	VOC	SW-846:8260B	Methylene Chloride	10	ug/L	U
10-2185	GW29-10-13276	VOC	SW-846:8260B	Naphthalene	1	ug/L	U
10-2185	GW29-10-13276	VOC	SW-846:8260B	Propionitrile	5	ug/L	U
10-2185	GW29-10-13276	VOC	SW-846:8260B	Propylbenzene[1-]	1	ug/L	U
10-2185	GW29-10-13276	VOC	SW-846:8260B	Styrene	1	ug/L	U
10-2185	GW29-10-13276	VOC	SW-846:8260B	Tetrachloroethane[1,1,1,2-]	1	ug/L	U
10-2185	GW29-10-13276	VOC	SW-846:8260B	Tetrachloroethane[1,1,2,2-]	1	ug/L	U

Table B-1.3-1 (continued)

Lab Request Number	Sample ID	Analytical Suite Code	Analytical Method	Analyte Description	Lab Result	Unit	Validation Qualifier Code
10-2185	GW29-10-13276	VOC	SW-846:8260B	Tetrachloroethene	1	ug/L	U
10-2185	GW29-10-13276	VOC	SW-846:8260B	Toluene	1	ug/L	U
10-2185	GW29-10-13276	VOC	SW-846:8260B	Trichloro-1,2,2-trifluoroethane[1,1,2-]	5	ug/L	U
10-2185	GW29-10-13276	VOC	SW-846:8260B	Trichlorobenzene[1,2,3-]	1	ug/L	U
10-2185	GW29-10-13276	VOC	SW-846:8260B	Trichlorobenzene[1,2,4-]	1	ug/L	U
10-2185	GW29-10-13276	VOC	SW-846:8260B	Trichloroethane[1,1,1-]	1	ug/L	U
10-2185	GW29-10-13276	VOC	SW-846:8260B	Trichloroethane[1,1,2-]	1	ug/L	U
10-2185	GW29-10-13276	VOC	SW-846:8260B	Trichloroethene	1	ug/L	U
10-2185	GW29-10-13276	VOC	SW-846:8260B	Trichlorofluoromethane	1	ug/L	U
10-2185	GW29-10-13276	VOC	SW-846:8260B	Trichloropropane[1,2,3-]	1	ug/L	U
10-2185	GW29-10-13276	VOC	SW-846:8260B	Trimethylbenzene[1,2,4-]	1	ug/L	U
10-2185	GW29-10-13276	VOC	SW-846:8260B	Trimethylbenzene[1,3,5-]	1	ug/L	U
10-2185	GW29-10-13276	VOC	SW-846:8260B	Vinyl acetate	5	ug/L	UJ
10-2185	GW29-10-13276	VOC	SW-846:8260B	Vinyl Chloride	1	ug/L	U
10-2185	GW29-10-13276	VOC	SW-846:8260B	Xylene[1,2-]	1	ug/L	U
10-2185	GW29-10-13276	VOC	SW-846:8260B	Xylene[1,3-]+Xylene[1,4-]	2	ug/L	U
10-2007	GW29-10-13277	HE	SW-846:8321A_MOD	2,4-Diamino-6-nitrotoluene	13	ug/L	UJ
10-2007	GW29-10-13277	HE	SW-846:8321A_MOD	2,6-Diamino-4-nitrotoluene	13	ug/L	UJ
10-2007	GW29-10-13277	HE	SW-846:8321A_MOD	3,5-Dinitroaniline	13	ug/L	UJ
10-2007	GW29-10-13277	HE	SW-846:8321A_MOD	Amino-2,6-dinitrotoluene[4-]	3.25	ug/L	UJ
10-2007	GW29-10-13277	HE	SW-846:8321A_MOD	Amino-4,6-dinitrotoluene[2-]	3.25	ug/L	UJ
10-2007	GW29-10-13277	HE	SW-846:8321A_MOD	Dinitrobenzene[1,3-]	3.25	ug/L	UJ
10-2007	GW29-10-13277	HE	SW-846:8321A_MOD	Dinitrotoluene[2,4-]	3.25	ug/L	UJ
10-2007	GW29-10-13277	HE	SW-846:8321A_MOD	Dinitrotoluene[2,6-]	3.25	ug/L	UJ
10-2007	GW29-10-13277	HE	SW-846:8321A_MOD	HMX	3.25	ug/L	UJ
10-2007	GW29-10-13277	HE	SW-846:8321A_MOD	Nitrobenzene	3.25	ug/L	UJ
10-2007	GW29-10-13277	HE	SW-846:8321A_MOD	Nitrotoluene[2-]	3.25	ug/L	UJ
10-2007	GW29-10-13277	HE	SW-846:8321A_MOD	Nitrotoluene[3-]	3.25	ug/L	R
10-2007	GW29-10-13277	HE	SW-846:8321A_MOD	Nitrotoluene[4-]	6.49	ug/L	R
10-2007	GW29-10-13277	HE	SW-846:8321A_MOD	PETN	13	ug/L	UJ
10-2007	GW29-10-13277	HE	SW-846:8321A_MOD	RDX	3.25	ug/L	UJ
10-2007	GW29-10-13277	HE	SW-846:8321A_MOD	TATB	13	ug/L	UJ
10-2007	GW29-10-13277	HE	SW-846:8321A_MOD	Tetryl	6.49	ug/L	UJ
10-2007	GW29-10-13277	HE	SW-846:8321A_MOD	Trinitrobenzene[1,3,5-]	3.25	ug/L	UJ
10-2007	GW29-10-13277	HE	SW-846:8321A_MOD	Trinitrotoluene[2,4,6-]	3.25	ug/L	UJ
10-2007	GW29-10-13277	HE	SW-846:8321A_MOD	Tris (o-cresyl) phosphate	13	ug/L	UJ
10-2007	GW29-10-13277	METALS	SW-846:6010B	Aluminum	4770	ug/L	NQ
10-2007	GW29-10-13277	METALS	SW-846:6020	Antimony	3	ug/L	U

Table B-1.3-1 (continued)

Lab Request Number	Sample ID	Analytical Suite Code	Analytical Method	Analyte Description	Lab Result	Unit	Validation Qualifier Code
10-2007	GW29-10-13277	METALS	SW-846:6010B	Arsenic	8.89	ug/L	J
10-2007	GW29-10-13277	METALS	SW-846:6010B	Barium	352	ug/L	NQ
10-2007	GW29-10-13277	METALS	SW-846:6020	Beryllium	0.452	ug/L	J
10-2007	GW29-10-13277	METALS	SW-846:6020	Cadmium	0.214	ug/L	J
10-2007	GW29-10-13277	METALS	SW-846:6010B	Calcium	26800	ug/L	NQ
10-2007	GW29-10-13277	METALS	SW-846:6010B	Chromium	25.6	ug/L	J
10-2007	GW29-10-13277	METALS	SW-846:6010B	Cobalt	78.5	ug/L	NQ
10-2007	GW29-10-13277	METALS	SW-846:6010B	Copper	33.5	ug/L	NQ
10-2007	GW29-10-13277	METALS	SW-846:6010B	Iron	51700	ug/L	NQ
10-2007	GW29-10-13277	METALS	SW-846:6020	Lead	4.26	ug/L	NQ
10-2007	GW29-10-13277	METALS	SW-846:6010B	Magnesium	6410	ug/L	NQ
10-2007	GW29-10-13277	METALS	SW-846:6020	Manganese	900	ug/L	NQ
10-2007	GW29-10-13277	METALS	SW-846:7470A	Mercury	0.2	ug/L	U
10-2007	GW29-10-13277	METALS	SW-846:6010B	Nickel	44	ug/L	NQ
10-2007	GW29-10-13277	METALS	SW-846:6010B	Potassium	4470	ug/L	NQ
10-2007	GW29-10-13277	METALS	SW-846:6010B	Selenium	30	ug/L	U
10-2007	GW29-10-13277	METALS	SW-846:6010B	Silver	5	ug/L	U
10-2007	GW29-10-13277	METALS	SW-846:6010B	Sodium	21600	ug/L	NQ
10-2007	GW29-10-13277	METALS	SW-846:6020	Thallium	1	ug/L	U
10-2007	GW29-10-13277	METALS	SW-846:6010B	Vanadium	16.2	ug/L	NQ
10-2007	GW29-10-13277	METALS	SW-846:6010B	Zinc	3320	ug/L	NQ
10-2007	GW29-10-13277	VOC	SW-846:8260B	Acetone	10	ug/L	UJ
10-2007	GW29-10-13277	VOC	SW-846:8260B	Acetonitrile	25	ug/L	U
10-2007	GW29-10-13277	VOC	SW-846:8260B	Acrolein	5	ug/L	U
10-2007	GW29-10-13277	VOC	SW-846:8260B	Acrylonitrile	5	ug/L	U
10-2007	GW29-10-13277	VOC	SW-846:8260B	Benzene	1	ug/L	U
10-2007	GW29-10-13277	VOC	SW-846:8260B	Bromobenzene	1	ug/L	U
10-2007	GW29-10-13277	VOC	SW-846:8260B	Bromochloromethane	1	ug/L	U
10-2007	GW29-10-13277	VOC	SW-846:8260B	Bromodichloromethane	1	ug/L	U
10-2007	GW29-10-13277	VOC	SW-846:8260B	Bromoform	1	ug/L	U
10-2007	GW29-10-13277	VOC	SW-846:8260B	Bromomethane	1	ug/L	U
10-2007	GW29-10-13277	VOC	SW-846:8260B	Butanol[1-]	50	ug/L	R
10-2007	GW29-10-13277	VOC	SW-846:8260B	Butanone[2-]	5	ug/L	U
10-2007	GW29-10-13277	VOC	SW-846:8260B	Butylbenzene[n-]	1	ug/L	U
10-2007	GW29-10-13277	VOC	SW-846:8260B	Butylbenzene[sec-]	1	ug/L	U
10-2007	GW29-10-13277	VOC	SW-846:8260B	Butylbenzene[tert-]	1	ug/L	U
10-2007	GW29-10-13277	VOC	SW-846:8260B	Carbon Disulfide	5	ug/L	UJ
10-2007	GW29-10-13277	VOC	SW-846:8260B	Carbon Tetrachloride	1	ug/L	U

Table B-1.3-1 (continued)

Lab Request Number	Sample ID	Analytical Suite Code	Analytical Method	Analyte Description	Lab Result	Unit	Validation Qualifier Code
10-2007	GW29-10-13277	VOC	SW-846:8260B	Chloro-1,3-butadiene[2-]	1	ug/L	U
10-2007	GW29-10-13277	VOC	SW-846:8260B	Chloro-1-propene[3-]	5	ug/L	U
10-2007	GW29-10-13277	VOC	SW-846:8260B	Chlorobenzene	1	ug/L	U
10-2007	GW29-10-13277	VOC	SW-846:8260B	Chlorodibromomethane	1	ug/L	U
10-2007	GW29-10-13277	VOC	SW-846:8260B	Chloroethane	1	ug/L	U
10-2007	GW29-10-13277	VOC	SW-846:8260B	Chloroform	1	ug/L	U
10-2007	GW29-10-13277	VOC	SW-846:8260B	Chloromethane	1	ug/L	UJ
10-2007	GW29-10-13277	VOC	SW-846:8260B	Chlorotoluene[2-]	1	ug/L	U
10-2007	GW29-10-13277	VOC	SW-846:8260B	Chlorotoluene[4-]	1	ug/L	U
10-2007	GW29-10-13277	VOC	SW-846:8260B	Dibromo-3-Chloropropane[1,2-]	1	ug/L	U
10-2007	GW29-10-13277	VOC	SW-846:8260B	Dibromoethane[1,2-]	1	ug/L	U
10-2007	GW29-10-13277	VOC	SW-846:8260B	Dibromomethane	1	ug/L	U
10-2007	GW29-10-13277	VOC	SW-846:8260B	Dichlorobenzene[1,2-]	1	ug/L	U
10-2007	GW29-10-13277	VOC	SW-846:8260B	Dichlorobenzene[1,3-]	1	ug/L	U
10-2007	GW29-10-13277	VOC	SW-846:8260B	Dichlorobenzene[1,4-]	1	ug/L	U
10-2007	GW29-10-13277	VOC	SW-846:8260B	Dichlorodifluoromethane	1	ug/L	UJ
10-2007	GW29-10-13277	VOC	SW-846:8260B	Dichloroethane[1,1-]	1	ug/L	U
10-2007	GW29-10-13277	VOC	SW-846:8260B	Dichloroethane[1,2-]	1	ug/L	U
10-2007	GW29-10-13277	VOC	SW-846:8260B	Dichloroethene[1,1-]	1	ug/L	U
10-2007	GW29-10-13277	VOC	SW-846:8260B	Dichloroethene[cis-1,2-]	1	ug/L	U
10-2007	GW29-10-13277	VOC	SW-846:8260B	Dichloroethene[trans-1,2-]	1	ug/L	U
10-2007	GW29-10-13277	VOC	SW-846:8260B	Dichloropropane[1,2-]	1	ug/L	U
10-2007	GW29-10-13277	VOC	SW-846:8260B	Dichloropropane[1,3-]	1	ug/L	U
10-2007	GW29-10-13277	VOC	SW-846:8260B	Dichloropropane[2,2-]	1	ug/L	U
10-2007	GW29-10-13277	VOC	SW-846:8260B	Dichloropropene[1,1-]	1	ug/L	U
10-2007	GW29-10-13277	VOC	SW-846:8260B	Dichloropropene[cis-1,3-]	1	ug/L	U
10-2007	GW29-10-13277	VOC	SW-846:8260B	Dichloropropene[trans-1,3-]	1	ug/L	U
10-2007	GW29-10-13277	VOC	SW-846:8260B	Diethyl Ether	1	ug/L	U
10-2007	GW29-10-13277	VOC	SW-846:8260B	Ethyl Methacrylate	5	ug/L	U
10-2007	GW29-10-13277	VOC	SW-846:8260B	Ethylbenzene	1	ug/L	U
10-2007	GW29-10-13277	VOC	SW-846:8260B	Hexachlorobutadiene	1	ug/L	U
10-2007	GW29-10-13277	VOC	SW-846:8260B	Hexanone[2-]	5	ug/L	U
10-2007	GW29-10-13277	VOC	SW-846:8260B	Iodomethane	5	ug/L	U
10-2007	GW29-10-13277	VOC	SW-846:8260B	Isobutyl alcohol	50	ug/L	R
10-2007	GW29-10-13277	VOC	SW-846:8260B	Isopropylbenzene	1	ug/L	U
10-2007	GW29-10-13277	VOC	SW-846:8260B	Isopropyltoluene[4-]	1	ug/L	U
10-2007	GW29-10-13277	VOC	SW-846:8260B	Methacrylonitrile	5	ug/L	U
10-2007	GW29-10-13277	VOC	SW-846:8260B	Methyl Methacrylate	5	ug/L	U

Table B-1.3-1 (continued)

Lab Request Number	Sample ID	Analytical Suite Code	Analytical Method	Analyte Description	Lab Result	Unit	Validation Qualifier Code
10-2007	GW29-10-13277	VOC	SW-846:8260B	Methyl tert-Butyl Ether	1	ug/L	U
10-2007	GW29-10-13277	VOC	SW-846:8260B	Methyl-2-pentanone[4-]	5	ug/L	U
10-2007	GW29-10-13277	VOC	SW-846:8260B	Methylene Chloride	10	ug/L	U
10-2007	GW29-10-13277	VOC	SW-846:8260B	Naphthalene	1	ug/L	U
10-2007	GW29-10-13277	VOC	SW-846:8260B	Propionitrile	5	ug/L	U
10-2007	GW29-10-13277	VOC	SW-846:8260B	Propylbenzene[1-]	1	ug/L	U
10-2007	GW29-10-13277	VOC	SW-846:8260B	Styrene	1	ug/L	U
10-2007	GW29-10-13277	VOC	SW-846:8260B	Tetrachloroethane[1,1,1,2-]	1	ug/L	U
10-2007	GW29-10-13277	VOC	SW-846:8260B	Tetrachloroethane[1,1,2,2-]	1	ug/L	U
10-2007	GW29-10-13277	VOC	SW-846:8260B	Tetrachloroethene	1	ug/L	U
10-2007	GW29-10-13277	VOC	SW-846:8260B	Toluene	1	ug/L	U
10-2007	GW29-10-13277	VOC	SW-846:8260B	Trichloro-1,2,2-trifluoroethane[1,1,2-]	5	ug/L	U
10-2007	GW29-10-13277	VOC	SW-846:8260B	Trichlorobenzene[1,2,3-]	1	ug/L	U
10-2007	GW29-10-13277	VOC	SW-846:8260B	Trichlorobenzene[1,2,4-]	1	ug/L	U
10-2007	GW29-10-13277	VOC	SW-846:8260B	Trichloroethane[1,1,1-]	1	ug/L	U
10-2007	GW29-10-13277	VOC	SW-846:8260B	Trichloroethane[1,1,2-]	1	ug/L	U
10-2007	GW29-10-13277	VOC	SW-846:8260B	Trichloroethene	1	ug/L	U
10-2007	GW29-10-13277	VOC	SW-846:8260B	Trichlorofluoromethane	1	ug/L	U
10-2007	GW29-10-13277	VOC	SW-846:8260B	Trichloropropane[1,2,3-]	1	ug/L	U
10-2007	GW29-10-13277	VOC	SW-846:8260B	Trimethylbenzene[1,2,4-]	1	ug/L	U
10-2007	GW29-10-13277	VOC	SW-846:8260B	Trimethylbenzene[1,3,5-]	1	ug/L	U
10-2007	GW29-10-13277	VOC	SW-846:8260B	Vinyl acetate	5	ug/L	UJ
10-2007	GW29-10-13277	VOC	SW-846:8260B	Vinyl Chloride	1	ug/L	U
10-2007	GW29-10-13277	VOC	SW-846:8260B	Xylene[1,2-]	1	ug/L	U
10-2007	GW29-10-13277	VOC	SW-846:8260B	Xylene[1,3-]+Xylene[1,4-]	2	ug/L	U
10-2007	GW29-10-13278	VOC	SW-846:8260B	Acetone	10	ug/L	UJ
10-2007	GW29-10-13278	VOC	SW-846:8260B	Acetonitrile	25	ug/L	U
10-2007	GW29-10-13278	VOC	SW-846:8260B	Acrolein	5	ug/L	U
10-2007	GW29-10-13278	VOC	SW-846:8260B	Acrylonitrile	5	ug/L	U
10-2007	GW29-10-13278	VOC	SW-846:8260B	Benzene	1	ug/L	U
10-2007	GW29-10-13278	VOC	SW-846:8260B	Bromobenzene	1	ug/L	U
10-2007	GW29-10-13278	VOC	SW-846:8260B	Bromochloromethane	1	ug/L	U
10-2007	GW29-10-13278	VOC	SW-846:8260B	Bromodichloromethane	1	ug/L	U
10-2007	GW29-10-13278	VOC	SW-846:8260B	Bromoform	1	ug/L	U
10-2007	GW29-10-13278	VOC	SW-846:8260B	Bromomethane	1	ug/L	U
10-2007	GW29-10-13278	VOC	SW-846:8260B	Butanol[1-]	50	ug/L	R
10-2007	GW29-10-13278	VOC	SW-846:8260B	Butanone[2-]	5	ug/L	U
10-2007	GW29-10-13278	VOC	SW-846:8260B	Butylbenzene[n-]	1	ug/L	U

Table B-1.3-1 (continued)

Lab Request Number	Sample ID	Analytical Suite Code	Analytical Method	Analyte Description	Lab Result	Unit	Validation Qualifier Code
10-2007	GW29-10-13278	VOC	SW-846:8260B	Butylbenzene[sec-]	1	ug/L	U
10-2007	GW29-10-13278	VOC	SW-846:8260B	Butylbenzene[tert-]	1	ug/L	U
10-2007	GW29-10-13278	VOC	SW-846:8260B	Carbon Disulfide	5	ug/L	UJ
10-2007	GW29-10-13278	VOC	SW-846:8260B	Carbon Tetrachloride	1	ug/L	U
10-2007	GW29-10-13278	VOC	SW-846:8260B	Chloro-1,3-butadiene[2-]	1	ug/L	U
10-2007	GW29-10-13278	VOC	SW-846:8260B	Chloro-1-propene[3-]	5	ug/L	U
10-2007	GW29-10-13278	VOC	SW-846:8260B	Chlorobenzene	1	ug/L	U
10-2007	GW29-10-13278	VOC	SW-846:8260B	Chlorodibromomethane	1	ug/L	U
10-2007	GW29-10-13278	VOC	SW-846:8260B	Chloroethane	1	ug/L	U
10-2007	GW29-10-13278	VOC	SW-846:8260B	Chloroform	1	ug/L	U
10-2007	GW29-10-13278	VOC	SW-846:8260B	Chloromethane	0.31	ug/L	J
10-2007	GW29-10-13278	VOC	SW-846:8260B	Chlorotoluene[2-]	1	ug/L	U
10-2007	GW29-10-13278	VOC	SW-846:8260B	Chlorotoluene[4-]	1	ug/L	U
10-2007	GW29-10-13278	VOC	SW-846:8260B	Dibromo-3-Chloropropane[1,2-]	1	ug/L	U
10-2007	GW29-10-13278	VOC	SW-846:8260B	Dibromoethane[1,2-]	1	ug/L	U
10-2007	GW29-10-13278	VOC	SW-846:8260B	Dibromomethane	1	ug/L	U
10-2007	GW29-10-13278	VOC	SW-846:8260B	Dichlorobenzene[1,2-]	1	ug/L	U
10-2007	GW29-10-13278	VOC	SW-846:8260B	Dichlorobenzene[1,3-]	1	ug/L	U
10-2007	GW29-10-13278	VOC	SW-846:8260B	Dichlorobenzene[1,4-]	1	ug/L	U
10-2007	GW29-10-13278	VOC	SW-846:8260B	Dichlorodifluoromethane	1	ug/L	UJ
10-2007	GW29-10-13278	VOC	SW-846:8260B	Dichloroethane[1,1-]	1	ug/L	U
10-2007	GW29-10-13278	VOC	SW-846:8260B	Dichloroethane[1,2-]	1	ug/L	U
10-2007	GW29-10-13278	VOC	SW-846:8260B	Dichloroethene[1,1-]	1	ug/L	U
10-2007	GW29-10-13278	VOC	SW-846:8260B	Dichloroethene[cis-1,2-]	1	ug/L	U
10-2007	GW29-10-13278	VOC	SW-846:8260B	Dichloroethene[trans-1,2-]	1	ug/L	U
10-2007	GW29-10-13278	VOC	SW-846:8260B	Dichloropropane[1,2-]	1	ug/L	U
10-2007	GW29-10-13278	VOC	SW-846:8260B	Dichloropropane[1,3-]	1	ug/L	U
10-2007	GW29-10-13278	VOC	SW-846:8260B	Dichloropropane[2,2-]	1	ug/L	U
10-2007	GW29-10-13278	VOC	SW-846:8260B	Dichloropropene[1,1-]	1	ug/L	U
10-2007	GW29-10-13278	VOC	SW-846:8260B	Dichloropropene[cis-1,3-]	1	ug/L	U
10-2007	GW29-10-13278	VOC	SW-846:8260B	Dichloropropene[trans-1,3-]	1	ug/L	U
10-2007	GW29-10-13278	VOC	SW-846:8260B	Diethyl Ether	1	ug/L	U
10-2007	GW29-10-13278	VOC	SW-846:8260B	Ethyl Methacrylate	5	ug/L	U
10-2007	GW29-10-13278	VOC	SW-846:8260B	Ethylbenzene	1	ug/L	U
10-2007	GW29-10-13278	VOC	SW-846:8260B	Hexachlorobutadiene	1	ug/L	U
10-2007	GW29-10-13278	VOC	SW-846:8260B	Hexanone[2-]	5	ug/L	U
10-2007	GW29-10-13278	VOC	SW-846:8260B	Iodomethane	5	ug/L	U
10-2007	GW29-10-13278	VOC	SW-846:8260B	Isobutyl alcohol	50	ug/L	R

Table B-1.3-1 (continued)

Lab Request Number	Sample ID	Analytical Suite Code	Analytical Method	Analyte Description	Lab Result	Unit	Validation Qualifier Code
10-2007	GW29-10-13278	VOC	SW-846:8260B	Isopropylbenzene	1	ug/L	U
10-2007	GW29-10-13278	VOC	SW-846:8260B	Isopropyltoluene[4-]	1	ug/L	U
10-2007	GW29-10-13278	VOC	SW-846:8260B	Methacrylonitrile	5	ug/L	U
10-2007	GW29-10-13278	VOC	SW-846:8260B	Methyl Methacrylate	5	ug/L	U
10-2007	GW29-10-13278	VOC	SW-846:8260B	Methyl tert-Butyl Ether	1	ug/L	U
10-2007	GW29-10-13278	VOC	SW-846:8260B	Methyl-2-pentanone[4-]	5	ug/L	U
10-2007	GW29-10-13278	VOC	SW-846:8260B	Methylene Chloride	10	ug/L	U
10-2007	GW29-10-13278	VOC	SW-846:8260B	Naphthalene	1	ug/L	U
10-2007	GW29-10-13278	VOC	SW-846:8260B	Propionitrile	5	ug/L	U
10-2007	GW29-10-13278	VOC	SW-846:8260B	Propylbenzene[1-]	1	ug/L	U
10-2007	GW29-10-13278	VOC	SW-846:8260B	Styrene	1	ug/L	U
10-2007	GW29-10-13278	VOC	SW-846:8260B	Tetrachloroethane[1,1,1,2-]	1	ug/L	U
10-2007	GW29-10-13278	VOC	SW-846:8260B	Tetrachloroethane[1,1,2,2-]	1	ug/L	U
10-2007	GW29-10-13278	VOC	SW-846:8260B	Tetrachloroethene	1	ug/L	U
10-2007	GW29-10-13278	VOC	SW-846:8260B	Toluene	1	ug/L	U
10-2007	GW29-10-13278	VOC	SW-846:8260B	Trichloro-1,2,2-trifluoroethane[1,1,2-]	5	ug/L	U
10-2007	GW29-10-13278	VOC	SW-846:8260B	Trichlorobenzene[1,2,3-]	1	ug/L	U
10-2007	GW29-10-13278	VOC	SW-846:8260B	Trichlorobenzene[1,2,4-]	1	ug/L	U
10-2007	GW29-10-13278	VOC	SW-846:8260B	Trichloroethane[1,1,1-]	1	ug/L	U
10-2007	GW29-10-13278	VOC	SW-846:8260B	Trichloroethane[1,1,2-]	1	ug/L	U
10-2007	GW29-10-13278	VOC	SW-846:8260B	Trichloroethene	1	ug/L	U
10-2007	GW29-10-13278	VOC	SW-846:8260B	Trichlorofluoromethane	1	ug/L	U
10-2007	GW29-10-13278	VOC	SW-846:8260B	Trichloropropane[1,2,3-]	1	ug/L	U
10-2007	GW29-10-13278	VOC	SW-846:8260B	Trimethylbenzene[1,2,4-]	1	ug/L	U
10-2007	GW29-10-13278	VOC	SW-846:8260B	Trimethylbenzene[1,3,5-]	1	ug/L	U
10-2007	GW29-10-13278	VOC	SW-846:8260B	Vinyl acetate	5	ug/L	UJ
10-2007	GW29-10-13278	VOC	SW-846:8260B	Vinyl Chloride	1	ug/L	U
10-2007	GW29-10-13278	VOC	SW-846:8260B	Xylene[1,2-]	1	ug/L	U
10-2007	GW29-10-13278	VOC	SW-846:8260B	Xylene[1,3-]+Xylene[1,4-]	2	ug/L	U

Notes: Sample GW29-10-13275 is a VOC trip blank for sample GW29=10-13276. Sample GW29-10-13278 is a VOC trip blank for sample GW29=10-13277.

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

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

[c] 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.

[d] HMX = Octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine.

[e] PETN = Pentaerythritol tetranitrate.

[f] RDX = Hexahydro-1,3,5-trinitro-1,3,5-triazine.

[g] TATB = Triaminotrinitrobenzene.

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

[i] 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.

[j] J + = The analyte was positively identified, and the result is likely to be biased high.

Table B-1.3-2
EES-14 Analytical Data

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)	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	ClO4(-) (U)	Co rslt (ppm)	stdev (Co)	Alk-CO3 rslt (ppm)
GW29-10-13277	2/22/2010	Borehole	10-2008	1175	0.001	U*	0.162	0.001	0.0010	0.0000	0.244	0.003	0.869	0.006	0.001	U	0.04	11.14	0.10	0.001	U	9.55	0.005	U	0.004	0.000	0.8
GW29-10-13276	3/1/2010	Borehole	10-2186	1248	0.001	U	0.090	0.000	0.0006	0.0000	0.070	0.001	0.454	0.005	0.001	U	0.04	8.42	0.04	0.001	U	4.77	0.005	U	0.007	0.000	0.8
GW29-10-13270	3/23/2010	Development	10-2558	1170-1180	0.001	U	0.007	0.000	0.0008	0.0000	0.058	0.001	0.208	0.001	0.001	U	0.03	10.51	0.07	0.001	U	4.10	0.005	U	0.001	U	0.8

Sample ID	Date Received	Sample Type	ALK-CO3 (U)	Cr rslt (ppm)	stdev (Cr)	Cs rslt (ppm)	stdev (Cs)	Cu rslt (ppm)	stdev (Cu)	F(-) ppm	Fe rslt (ppm)	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)	Mo rslt (ppm)	stdev (Mo)	Na rslt (ppm)
GW29-10-13277	2/22/2010	Borehole	U	0.007	0.000	0.001	U	0.001	U	0.37	0.64	0.01	114	0.00037	0.00000	2.30	0.03	0.048	0.006	4.04	0.02	0.114	0.001	0.012	0.000	23.35
GW29-10-13276	3/1/2010	Borehole	U	0.003	0.000	0.001	U	0.001	U	0.25	0.40	0.00	69	0.00011	0.00001	1.14	0.01	0.020	0.000	2.69	0.03	0.078	0.001	0.002	0.000	11.11
GW29-10-13270	3/23/2010	Development	U	0.004	0.000	0.001	U	0.002	0.000	0.22	0.31	0.00	81	0.00008	0.00001	1.20	0.01	0.023	0.001	3.34	0.01	0.045	0.000	0.002	0.000	16.29

Sample ID	Date Received	Sample Type	stdev (Na)	Ni rslt (ppm)	stdev (Ni)	NO2 (ppm)	NO2-N rslt	NO3 ppm	NO3-N rslt	C2O4 rslt (ppm)	Pb rslt (ppm)	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)	stdev (SiO2)	Sn rslt (ppm)	stdev (Sn)	SO4(-2) rslt (ppm)	Sr rslt (ppm)
GW29-10-13277	2/22/2010	Borehole	0.11	0.006	0.003	0.12	0.037	1.53	0.35	0.01, U	0.0002	U	7.48	0.26	0.001	0.000	0.001	U	0.002	0.000	18.1	0.1	38.7	0.2	0.001	U	3.97	0.046
GW29-10-13276	3/1/2010	Borehole	0.07	0.002	0.000	0.01	0.003, U	1.91	0.43	0.01, U	0.0002	U	6.98	0.15	0.001	U	0.001	U	0.001	U	30.6	0.2	65.6	0.3	0.001	U	2.84	0.040
GW29-10-13270	3/23/2010	Development	0.08	0.002	0.000	0.01	0.003, U	1.97	0.44	0.01, U	0.0002	U	7.23	0.05	0.001	U	0.001	U	0.001	U	30.2	0.1	64.6	0.1	0.001	U	9.84	0.048

Sample ID	Date Received	Sample Type	stdev (Sr)	Th rslt (ppm)	stdev (Th)	Ti rslt (ppm)	stdev (Ti)	Tl rslt (ppm)	stdev (Tl)	U rslt (ppm)	stdev (U)	U rslt (ppm)	V rslt (ppm)	stdev (V)	Zn rslt (ppm)	stdev (Zn)	TDS (ppm)	Cations	Anions	Balance
GW29-10-13277	2/22/2010	Borehole	0.002	0.001	U	0.002	U	0.001	U	0.0003	0.0000	0.0003	0.002	0.000	0.093	0.003	228	1.99	2.63	-0.14
GW29-10-13276	3/1/2010	Borehole	0.000	0.001	U	0.006	0.000	0.001	U	0.0002	0.0000	0.0002	0.003	0.000	0.066	0.011	170	1.17	1.40	-0.09
GW29-10-13270	3/23/2010	Development	0.000	0.001	U	0.002	U	0.001	U	0.0006	0.0000	0.0006	0.005	0.000	0.041	0.000	195	1.55	1.73	-0.06

*U = The analyte was analyzed for but not detected.

Table B-1.3-3
TOC Concentrations

Sample ID	Analyte Description	Lab Result	Unit	Validation Qualifier Code
GW-29-10-13271	TOC	1	mg/L	U[a]
GW-29-10-13272	TOC	0.25	mg/L	NQ[b]
GW-29-10-13270	TOC	0.30	mg/L	NQ

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

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

Appendix C

Aquifer Testing Report

C-1.0 INTRODUCTION

This appendix describes the hydraulic analysis of pumping tests conducted in March 2010 at well R-29 located at Technical Area 49 (TA-49) at Los Alamos National Laboratory (the Laboratory). The tests on R-29 were conducted to evaluate the hydraulic properties of the Puye Formation sediments in which the well was completed.

Testing consisted of brief trial pumping of R-29, background water level data collection, and a 24-h constant-rate pumping test. As with most of the R-well pumping tests conducted on the Pajarito Plateau (the Plateau), an inflatable packer system was used in R-29 to minimize the effects of casing storage on the test data.

As described below, air or gas in the formation affected a portion of the data collected during the pumping tests. Numerous pumping tests conducted recently on the Plateau have shown this effect. It was assumed that the source of the gas was compressed air introduced into the formation during the drilling process. It is possible, however, that naturally occurring gas could be responsible for the observed effect.

Conceptual Hydrogeology

Well R-29 is drilled into sediments of the Puye Formation. The well was completed with 10 ft of 5-in. stainless-steel well screen from 1170 to 1180 ft below ground surface (bgs). The static water level measured on March 21, 2010, was 1152.5 ft bgs, 17.5 ft above the top of the well screen. The estimated ground surface elevation at R-29 was 7097 ft above mean sea level (amsl), making the water level approximately 5944.5 ft amsl.

No distinctive aquitards or other tight zones were identified for R-29, so the permeability distribution of the saturated zone and the effective aquifer thickness in the vicinity of the well were not well defined.

R-29 Testing

Well R-29 was tested from March 21 to 26, 2010. After filling the drop pipe on March 21, testing consisted of brief trial pumping on March 22, background data collection, and a 24-h constant-rate pumping test that began on March 24.

Two trial tests were conducted on March 22. Trial 1 was conducted at a discharge rate of 4.07 gallons per minute (gpm) for 30 min from 10:30 to 11:00 a.m. and was followed by 60 min of recovery until 12:00 p.m.

Trial 2 was conducted for 60 min from 12:00 to 1:00 p.m. at a discharge rate of 4.05 gpm. Following shutdown, recovery data were recorded for 2580 min until 8:00 a.m. on March 24.

At 8:00 a.m. on March 24, the 24-h pumping test was begun at a rate of 4.04 gpm. After a few hours, the rate inexplicably increased gradually, reaching a maximum of 4.3 gpm before midnight, less than 16 h into the test. It was surmised that varying gas content in the pumped water may have affected the pump bowl efficiency and the resulting pumping rate.

Just before midnight on March 24, the discharge rate began declining steadily and continued to do so throughout the remainder of the pumping test. By the end of the test, the discharge rate had declined to 0.4 gpm. It was surmised that steady buildup of gas or air within the casing beneath the inflatable packer gradually forced the water level in the well downward, reducing the distance between the water level and the pump intake, limiting the available drawdown for pumping.

At 8:00 a.m. on March 25, the pump was shut off. Following shutdown, recovery measurements were recorded for 1410 min until 7:30 a.m. on March 26.

C-2.0 BACKGROUND DATA

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

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

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

Subsequent pumping tests, including at R-29, have utilized nonvented transducers. These devices simply 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 a well is 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 the 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 approximately 7097 ft amsl. The static water level in R-29 was 1152.5 ft below land surface, making the calculated water-table elevation 5944.5 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-29.

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

$$P_{WT} = P_{TA54} \exp\left[-\frac{g}{3.281R}\left(\frac{E_{R-29} - E_{TA54}}{T_{TA54}} + \frac{E_{WT} - E_{R-29}}{T_{WELL}} \right) \right] \qquad \textbf{Equation C-1}$$

where, P_{WT} = barometric pressure at the water table inside R-29

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

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

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

E_{R-29} = land surface elevation at R-29 site, in feet (approximately 7097 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-29, in feet (approximately 5944.5 ft)

T_{TA54} = air temperature near TA-54, in degrees kelvin (assigned a value of 36.4 degrees Fahrenheit, or 275.6 degrees kelvin)

T_{WELL} = air temperature inside R-29, in degrees kelvin (assigned a value of 59.7 degrees Fahrenheit, or 288.5 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 the data are analyzed.

C-3.0 IMPORTANCE OF EARLY DATA

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

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

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

Equation C-2

where, t_c = duration of casing-storage effect, in minutes

D = inside diameter of well casing, in inches

d = outside diameter of column pipe, in inches

Q = discharge rate, in gallons per minute

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

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

For wells screened across the water table (not applicable here), 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 C-3**

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

D_B = diameter of borehole, in inches

D_C = outside diameter of well casing, in inches

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

In some instances, it is possible to eliminate casing storage effects by setting an inflatable packer above the tested screen interval before conducting the test. Therefore, this option has been implemented for the R-well testing program, including R-29.

C-4.0 TIME-DRAWDOWN METHODS

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

$$s = \frac{114.6Q}{T} W(u)$$ **Equation C-4**

where,

$$W(u) = \int_u^{\infty} \frac{e^{-x}}{x} dx$$ **Equation C-5**

and

$$u = \frac{1.87 r^2 S}{Tt}$$ **Equation C-6**

and where, s = drawdown, in feet

Q = discharge rate, in gallons per minute

T = transmissivity, in gallons per day per foot

S = storage coefficient (dimensionless)

t = pumping time, in days

r = distance from center of pumpage, in feet

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

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

Equation C-7

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

Equation C-8

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

S = storage coefficient

Q = discharge rate, in gallons per minute

$W(u)$ = match-point value

s = match-point value, in feet

u = match-point value

t = match-point value, in minutes

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

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

Equation C-9

The Cooper-Jacob equation is a simplified approximation of the Theis equation and is valid whenever the *u* value is less than about 0.05. For small radius values (e.g., corresponding to borehole radii), *u* is less than 0.05 at very early pumping times and therefore is less than 0.05 for most or all measured drawdown values. Thus, for the pumped well, the Cooper-Jacob equation usually can be considered a valid approximation of the Theis equation.

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

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

Equation C-10

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

Q = discharge rate, in gallons per minute

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

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

Equation C-11

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

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

b = aquifer thickness

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

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

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

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

K_z = vertical hydraulic conductivity

K_r = horizontal hydraulic conductivity

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

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

Equation C-12

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

C-5.0 RECOVERY METHODS

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

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

$$T = \frac{264Q}{\Delta s}$$ **Equation C-13**

The recovery data are particularly useful compared 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.

C-6.0 SPECIFIC CAPACITY METHOD

The specific capacity of the pumped well can be used to obtain a lower-bound value of hydraulic conductivity. The hydraulic conductivity is computed using formulas 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 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:

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

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

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

To apply this procedure, a storage coefficient value must be assigned. Unconfined conditions were assumed for R-29 because of the modest water level rise above the well screen. Storage coefficient values for unconfined conditions can be expected to range from about 0.01 to 0.25 (Driscoll 1986, 104226). A value of 0.1 was used for the R-29 calculations. The calculation result is not particularly sensitive to the choice of storage coefficient value, so a rough estimate of the storage coefficient is generally adequate to support the calculations.

The analysis also requires assigning a value for the saturated aquifer thickness, b. For the purposes of this exercise, an arbitrary saturated thickness of 30 ft was assigned. As long as the aquifer thickness is greater than the well-screen length, the calculation result is not especially sensitive to the selected value because sediments far above and/or below the screen do not contribute significantly to the specific capacity.

C-7.0 BACKGROUND DATA ANALYSIS

Background aquifer pressure data collected during the R-29 tests were plotted along with barometric pressure to determine the barometric effect on water levels.

Figure C-7.0-1 shows aquifer pressure data from R-29 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-29 data are referred to in the figure as the “apparent hydrograph” because the measurements reflect the sum of water pressure and barometric pressure, having been recorded using a nonvented pressure transducer. The times of the pumping periods for the R-29 pumping tests are included in the figure for reference.

The data from March 25 and 26 on Figure C-7.0-1 showed virtually no change in aquifer pressure during a period of large barometric pressure change. This finding suggested a barometric efficiency of close to 100% and implied that water-level measurements did not have to be adjusted for changes in barometric pressure.

A rise in aquifer pressure of a couple hundredths of a foot occurred on March 23 just before midnight. The cause of this “blip” was not identified, although one possibility is that it may have been a result of drilling activities at R-30 (0.3 mi away) that were underway at that time. Another possibility is that the pumping string (pump, pipe and packer) may have shifted or settled slightly.

C-8.0 WELL R-29 DATA ANALYSIS

This section presents the data obtained from the R-29 pumping tests and the results of the analytical interpretations. Data are presented for drawdown and recovery for trials 1 and 2 as well as drawdown from the 24-h constant-rate pumping test.

C-8.1 Well R-29 Trial 1

Figure C-8.1-1 shows a semilog plot of the drawdown data collected from trial 1. Two parallel traces were evident in the data, separated by a gradual transition about a minute after pumping began. This likely was a response to a pumping rate decline that occurred as the discharge hose filled to the elevation of the top of the storage tank, about 10 ft above ground level. The increase in head reduced the discharge rate slightly.

The transmissivity calculated from the line of fit shown on the graph was 630 gallons per day (gpd) per foot. The saturated thickness corresponding to this transmissivity value could not be determined, precluding calculating a corresponding hydraulic conductivity.

Figure C-8.1-2 shows the recovery data collected following shutdown of the trial 1 pumping test. Two distinct slopes were evident on the graph. The early slope supported a transmissivity calculation of 370 gpd/ft. It was assumed this represented the transmissivity of just the 10-ft-thick screened interval, making the hydraulic conductivity 37 gpd/ft^2, or 4.9 ft/d.

The late-time slope yielded a transmissivity of 780 gpd/ft. It was assumed this value represented an unknown contiguous thickness of permeable sediments in which the screen is placed.

Note that nearly full recovery occurred prematurely, well before a *t/t'* value of 1.0, possibly an indication of hysteretic effects. In unconfined aquifers, the rate of recovery can be more rapid than that of drawdown because of a smaller effective storage coefficient during recovery. During pumping, the capillary fringe above the water table increases in thickness, while during recover it gets thinner (Bevan et al. 2005, 105186). If the rate of thinning during recovery exceeds the rate of growth during pumping, the effective storage coefficient during recovery will be less than that during pumping, resulting in a more rapid recovery rate than drawdown rate. Additionally, as the water table rebounds during recovery, it can trap air in the previously dewatered pore spaces, further decreasing the effective recovery storage coefficient. It was also possible that extraneous air already in the formation, or air that was dissolved in the groundwater and came out of solution during pumping, contributed to a reduced storage coefficient.

C-8.2 Well R-29 Trial 2

Figure C-8.2-1 shows a semilog plot of the drawdown data collected from trial 2. The early inertial effect masked the early-time data trend. The late data produced a transmissivity value of 690 gpd/ft for the contiguous hydraulic unit of unknown thickness penetrated by the well screen, consistent with the results from trial 1.

Figure C-8.2-2 shows the recovery data collected following shutdown of the trial 2 pumping test. The early data yielded a transmissivity of 390 gpd/ft with a corresponding average hydraulic conductivity for the screened interval of 39 gpd/ft^2, or 5.2 ft/d. The very early data points fell off the line of fit shown on the graph, probably because the u value was greater than 0.05.

The late data shown in Figure C-8.2-2 suggested a formation transmissivity of 730 gpd/ft for the entire contiguous aquifer zone, consistent with previous results.

Because of the u-value limitations suggested by the data plot, the early-time data were analyzed using Theis curve matching as shown in Figure C-8.2-3. The data match was better than the straight-line fit, although a few of the early data points still fell off the type curve, likely an indication of inertial effects. (Because these data approached the type curve from above, rather than below, storage effects were ruled out.) The Theis analysis suggested a transmissivity value of 380 gpd/ft and a corresponding hydraulic conductivity of 38 gpd/ft^2, or 5.1 ft/d.

C-8.3 Well R-29 24-H Constant-Rate Pumping Test

Figure C-8.3-1 shows a semilog plot of the drawdown data collected during the 24-h pumping test. The data collected during the first 200 min of the test (at a pumping rate of 4.04 gpm) supported a transmissivity value calculation of 770 gpd/ft for the contiguous hydraulic unit penetrated by the well screen. This value was in agreement with previous results.

Between 200 and 900 min, the discharge rate increased steadily to 4.3 gpm, with a corresponding increase in drawdown. Analysis showed that the drawdown increase was greater than the discharge rate increase. It is likely that gas or air in the formation contributed to the unusual pumping rate and drawdown responses shown. For example, a gradual reduction in gas content in the pumped water would allow the pump bowl to operate more efficiently, increasing the flow rate. Meanwhile, gradual accumulation of gas in the formation could reduce the permeability and increase the drawdown disproportionately. These explanations are speculative. However, it is certain that a submersible pump cannot produce both increased flow and increased head unless its efficiency changes, so it was likely that air or gas in the groundwater influenced the operation.

After a little more than 900 min of pumping, the discharge rate began to decline steadily throughout the balance of the pumping test, reaching 0.4 gpm by the end of the pumping period. As a result, the measured drawdown declined steadily as well. The gap in the data at around 1100 min occurred when the pumping rate was adjusted manually by reducing the pump rotational speed using the variable frequency drive unit operating the pump.

The drawdown data were replotted on a linear scale as shown in Figure C-8.3-2. Because late-time drawdown is roughly proportional to discharge rate, the shape of the drawdown curve can serve as a surrogate of the discharge rate itself. Thus, the linear drawdown plot conveyed a sense of the change that was occurring in the pumping rate late in the test, providing a vivid illustration of the observed reduction in discharge rate over time.

It was hypothesized that gas or air from the groundwater accumulated in the well casing beneath the inflatable packer forming a “bubble” above the pump. As the bubble grew, it pushed the water level in the casing lower, eventually driving it down to the pump intake. At that point, further accumulation of gas or air would effectively reduce the available drawdown for the pump, forcing a reduction in discharge rate.

Because of the dramatic changes in discharge rate during the final hours of pumping, the recovery data were not usable and are not included here.

C-8.4 Well R-29 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-29 to provide a frame of reference for evaluating the above analyses.

During the 24-h pumping test, the discharge rate remained constant at 4.04 gpm for 180 min with a drawdown of 6.55 ft, making the specific capacity 0.62 gpm/ft at that time. In addition to specific capacity and pumping time, other input values used in the calculations included a storage coefficient value of 0.1, an arbitrary aquifer thickness of 30 ft, and a borehole radius of 0.63 ft (inferred from the volume of filter pack required to backfill the screen zone).

Applying the Brons and Marting method to these inputs yielded a lower-bound hydraulic conductivity of 38 gpd/ft^2, or 5.1 ft/d. This value coincided with the average hydraulic conductivity obtained from analysis of the early recovery data from the trial pumping tests, providing good corroboration of the results.

C-9.0 SUMMARY

Constant-rate pumping tests were conducted on R-29 to gain an understanding of the hydraulic characteristics of the Puye Formation sediments in which R-29 is screened. Several observations and conclusions were drawn for the tests as summarized below.

A comparison of barometric pressure and R-29 water-level data suggested a barometric efficiency near 100%.

Transmissivity values computed from early data averaged 380 gpd/ft, making the average hydraulic conductivity of the screened interval 38 gpd/ft^2, or 5.1 ft/d. The late data produced an average transmissivity of 720 gpd/ft, presumably the transmissivity of the contiguous aquifer of unknown thickness penetrated by the well.

R-29 produced 4.04 gpm with 6.55 ft of drawdown after 180 min of pumping, resulting in a specific capacity of 0.62 gpm/ft at that particular pumping time. The corresponding computed lower-bound hydraulic conductivity value was 38 gpd/ft^2, the same as the average of the pumping-test values.

After 180 min, the discharge rate and drawdown increased gradually over the next 12 h or so. It was presumed that varying gas or air content in the formation pores and pumped groundwater caused the observed changes.

During the final 8 h of the 24-h pumping test, the discharge rate declined steadily from 4.3 to 0.4 gpm. It was likely than accumulation of gas beneath the inflatable packer forced the water level down to the pump intake, restricting the available drawdown and, thus, reducing the pumping rate..

C-10.0 REFERENCES

The following list includes all documents cited in this appendix. Parenthetical information following each reference provides the author(s), publication date, and ER ID. 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.

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

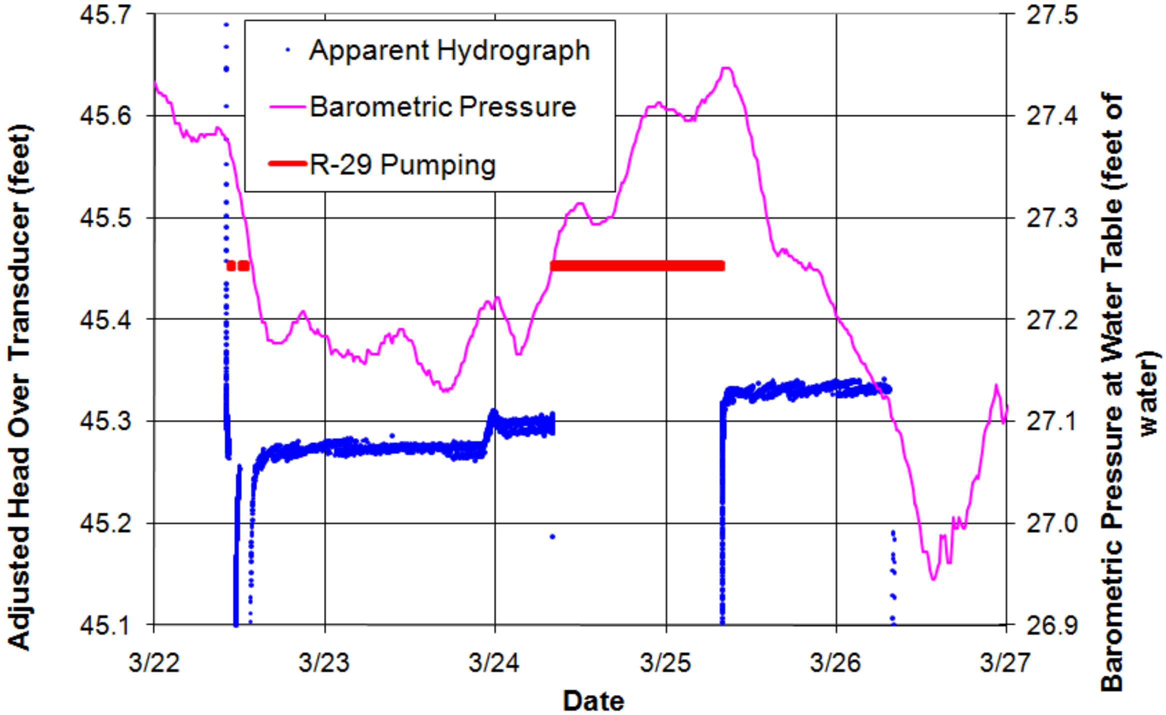


Figure C-7.0-1 Well R-29 apparent hydrograph

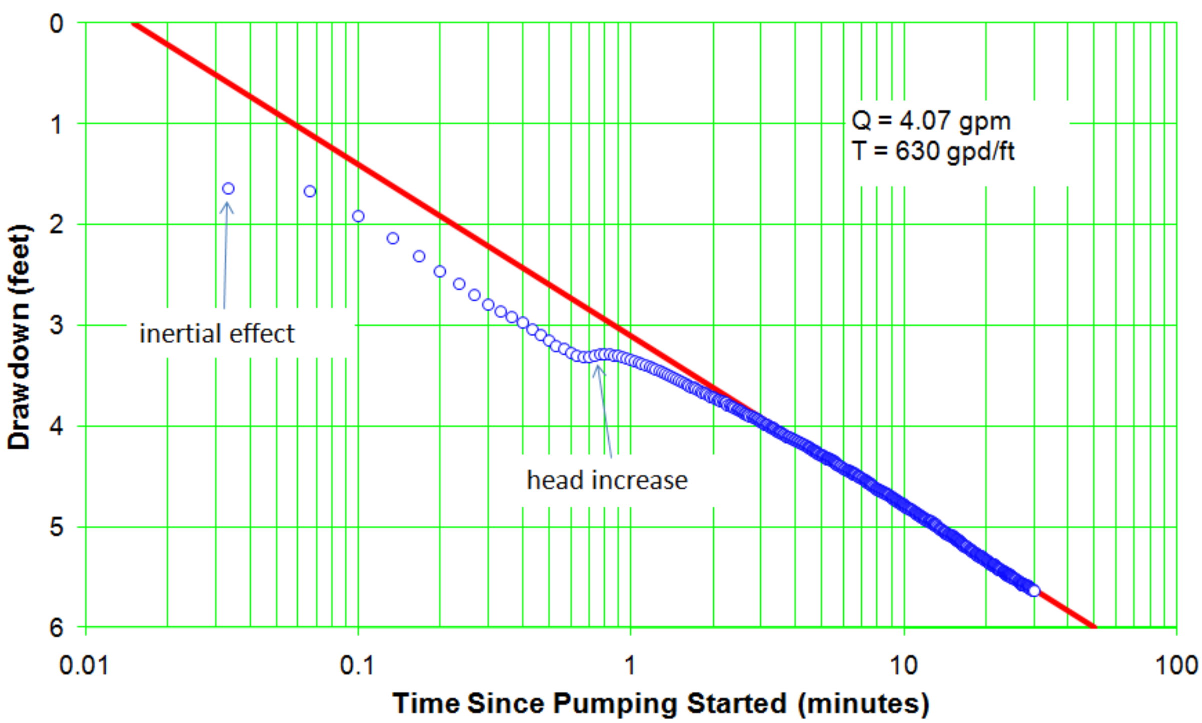


Figure C-8.1-1 Well R-29 trial 1 drawdown

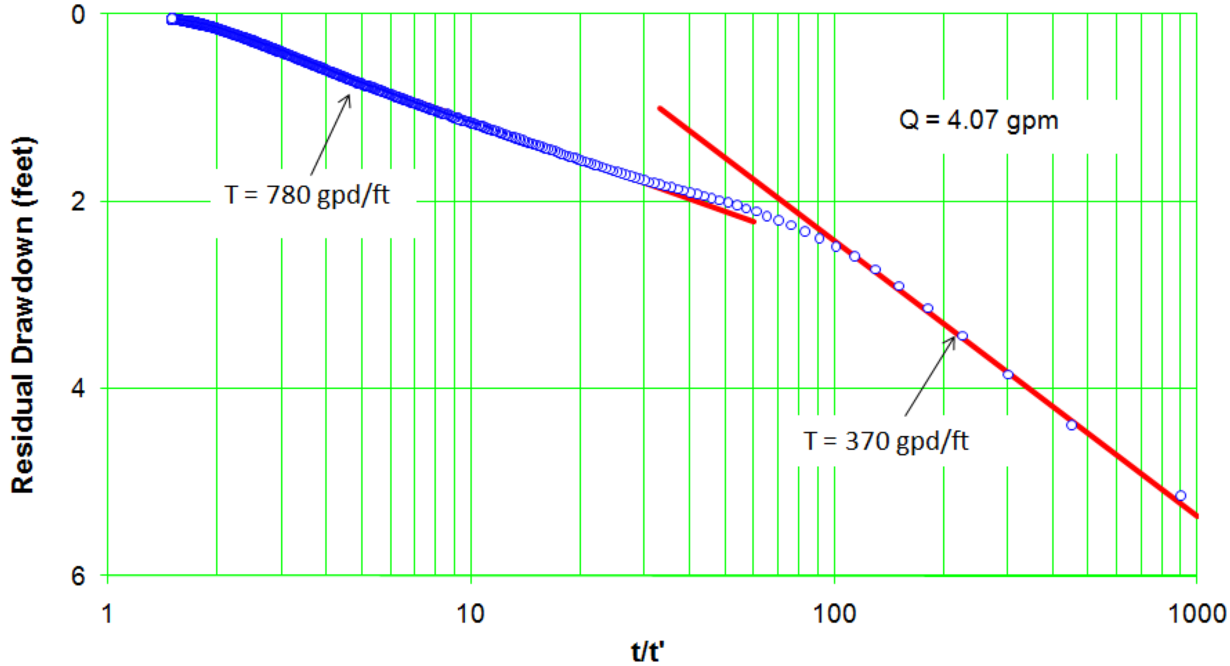


Figure C-8.1-2 Well R-29 trial 1 recovery

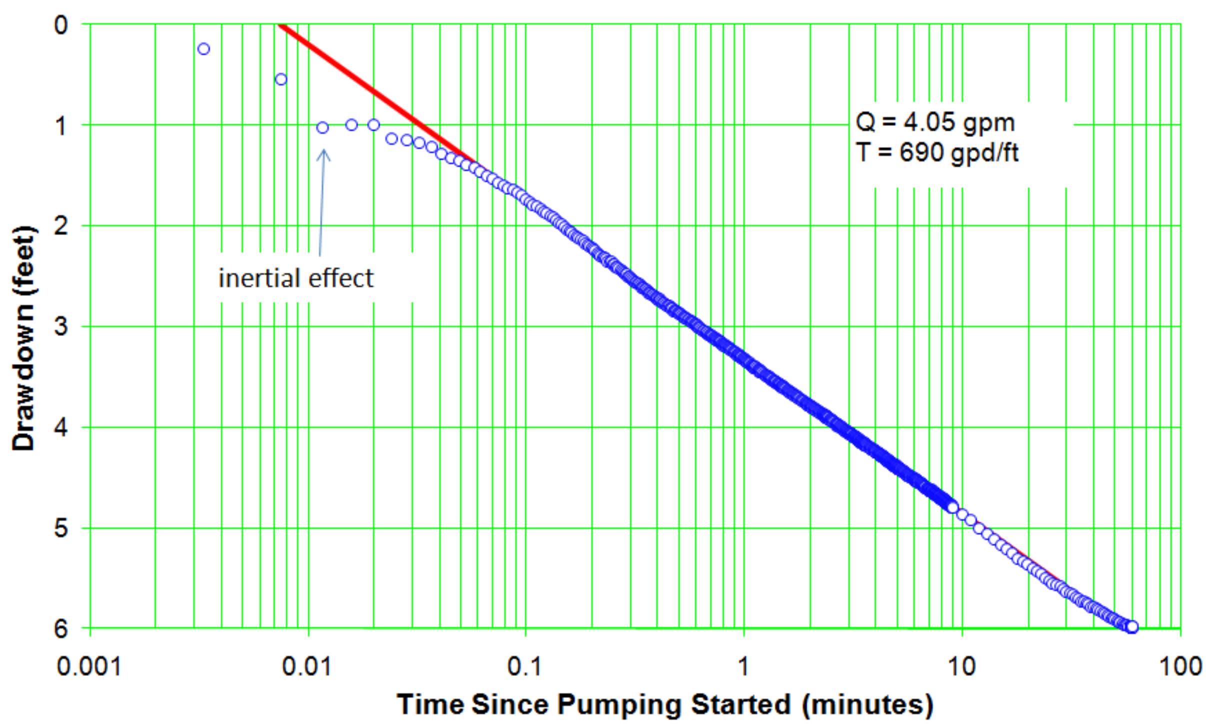


Figure C-8.2-1 Well R-29 trial 2 drawdown

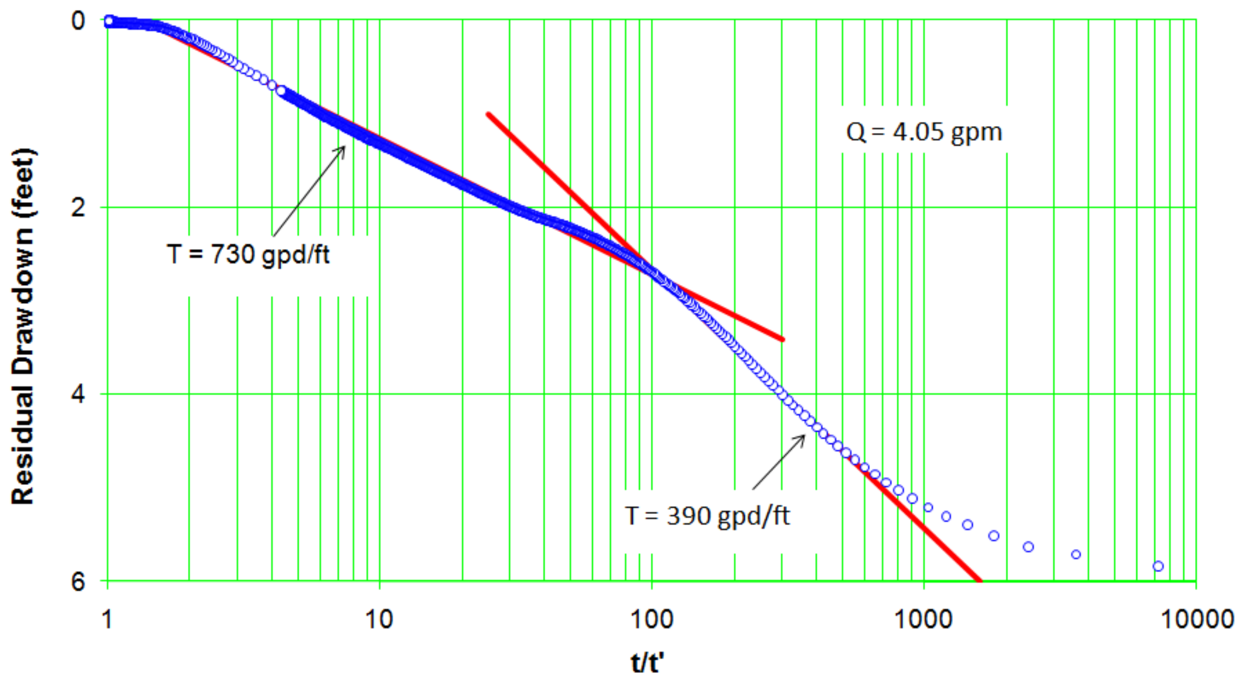


Figure C-8.2-2 Well R-29 trial 2 recovery

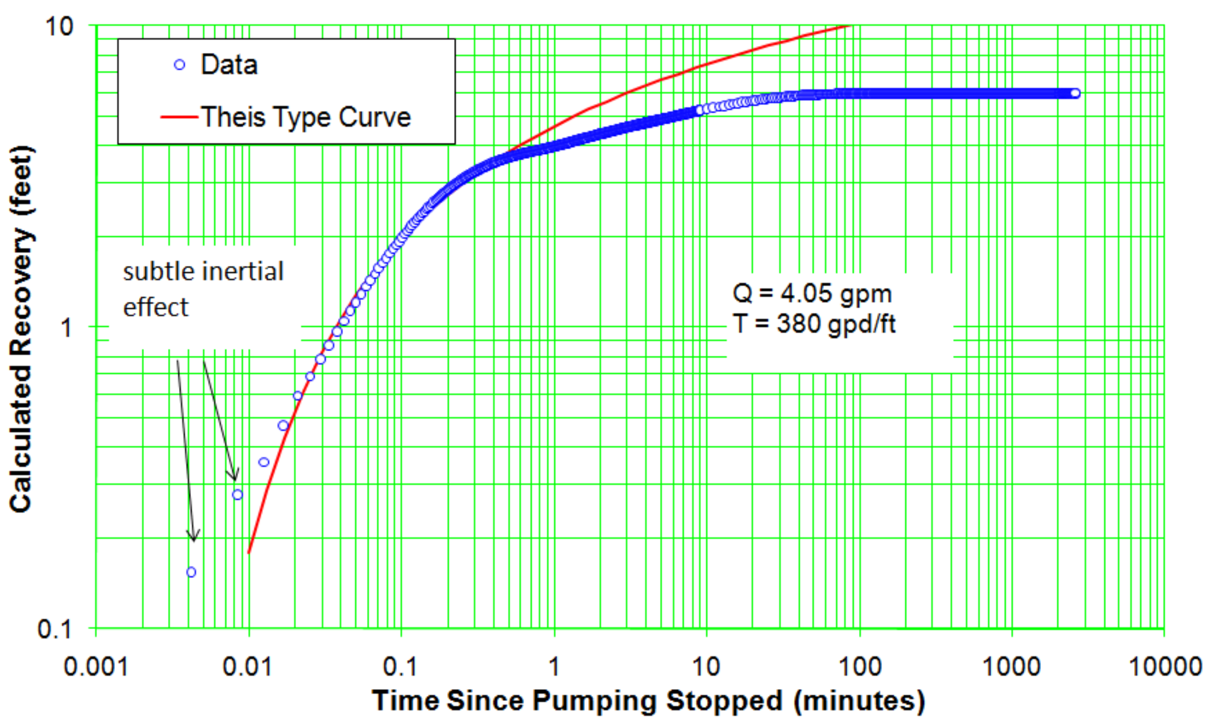


Figure C-8.2-3 Well R-29 trial 2 early recovery—Theis analysis

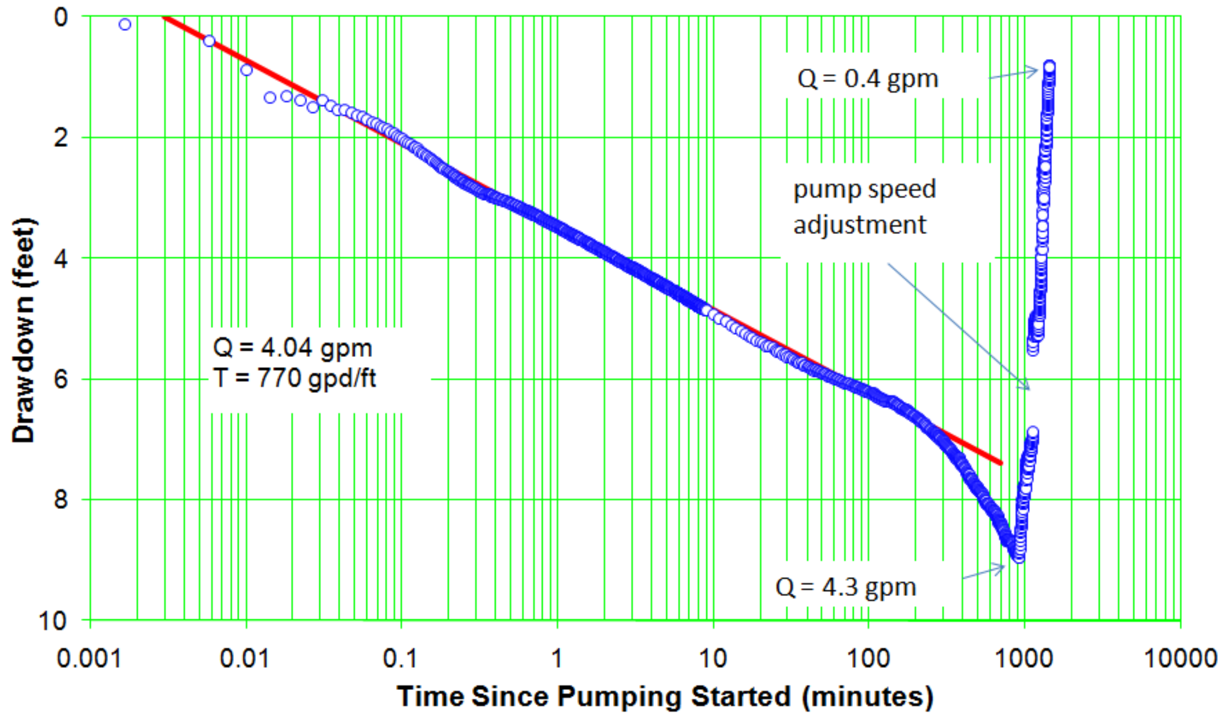


Figure C-8.3-1 Well R-29 drawdown

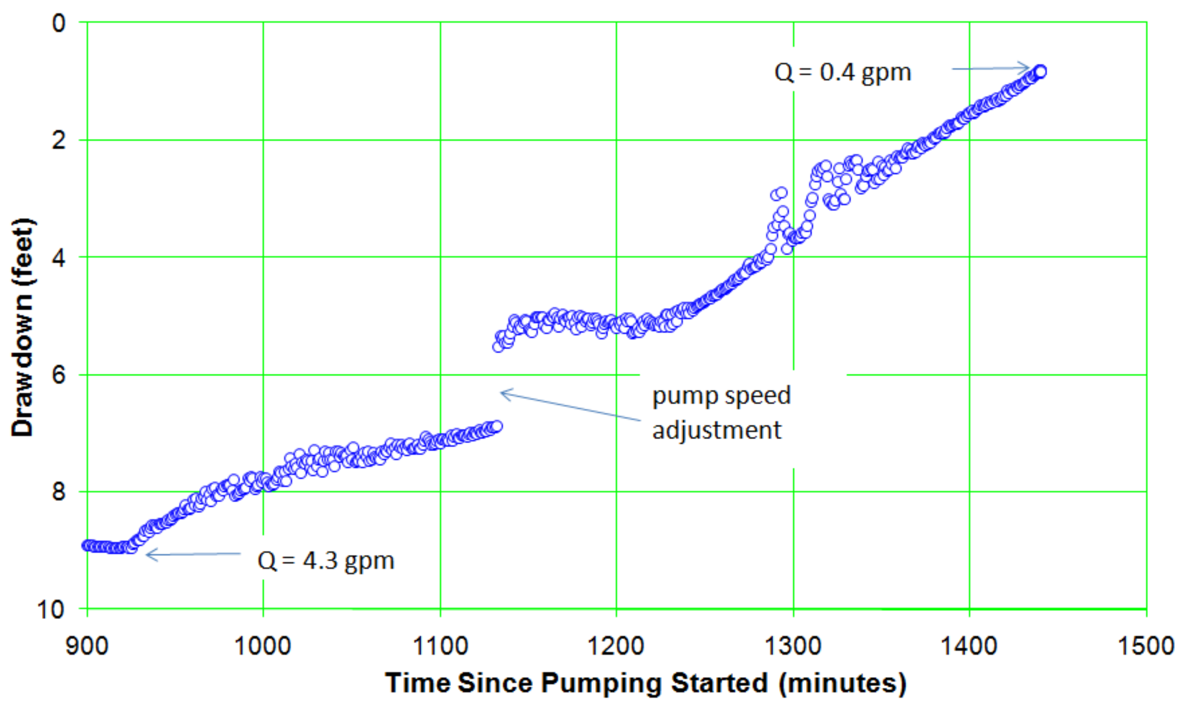


Figure C-8.3-2 Well R-29 drawdown—linear plot

Appendix D

Borehole Video Logging
(on DVD included with this document)

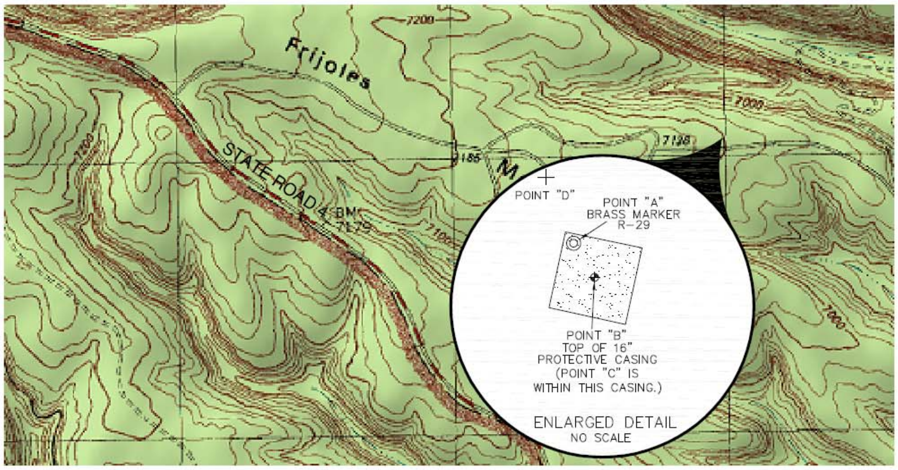
Appendix E

Geophysical Log Logging Report
(on CD included with this document)

Appendix F

Geodetic Survey

LANL MONITORING WELL LOCATION REPORT
DESIGNATED R-29
WITHIN TECHNICAL AREA 49
LOS ALAMOS NATIONAL LABORATORY
LOS ALAMOS COUNTY, NEW MEXICO
JUNE, 2010



POINT	DESCRIPTION	EASTING (X)	NORTHING (Y)	ELEVATION
A	BRASS MARKER R-29	1626779.91	1755383.32	7100.75
B	TOP OF 16" PROTECTIVE CASING	1626782.59	1755378.94	7103.40
C	TOP OF 6" WELL	1626782.64	1755378.87	7102.91
D	GROUND	1626776.38	1755391.80	7100.34

Notes

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

2.) THIS AREA LIES WITHIN LOS ALAMOS NATIONAL LABORATORY PROPERTY IN TECHNICAL AREA 49, 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.

L.W. Medrano

LARRY W. MEDRANO, N.M.P.L.S. NO. 11993 *DATE* 07/14/2010

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