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Date: March 16, 2009
Refer To: EP2009-0141

James P. Bearzi, Bureau Chief
Hazardous Waste Bureau
New Mexico Environment Department
2905 Rodeo Park Drive East, Building 1
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Subject: Submittal of the Completion Report for Wells R-43 and SCI-2

Dear Mr. Bearzi:

Enclosed please find two hard copies with electronic files of the Completion Report for Wells R-43 and SCI-2.

If you have any questions, please contact Mark Everett at (505) 667-5931 (meverett@lanl.gov) or Nancy Werdel at (505) 665-3619 (nwerdel@doeal.gov).

Sincerely,

B G Schappell for

Michael J. Graham, Associate Director
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Los Alamos National Laboratory

Sincerely,

Elie P. Watts for

David R. Gregory, Project Director
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Los Alamos Site Office

MG/DG/PH/ME/SW:sm

Enclosures: Two hard copies with electronic files – Completion Report for Wells R-43 and SCI-2 (LA-UR-09-1337)

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LA-UR-09-1337
March 2009
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Completion Report for Wells R-43 and SCI-2

Los Alamos
NATIONAL LABORATORY
EST.1943

Prepared by the Environmental Programs Directorate

LA-UR-09-1337
EP2009-0141

Completion Report for Wells R-43 and SCI-2

March 2009

Responsible project leader:

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EXECUTIVE SUMMARY

This well completion report describes the drilling, installation, development, and aquifer testing of intermediate and regional wells SCI-2 and R-43, located in Sandia Canyon, Technical Area 72 (TA-72) at Los Alamos National Laboratory (the Laboratory) in Los Alamos County, New Mexico. This report was written in accordance with the requirements in Section IV.A.3.e.iv of the March 1, 2005, Compliance Order on Consent. These two wells were installed in an area west and upgradient of well R-11 at the direction of the New Mexico Environment Department (NMED), and all activities followed guidelines set forth by NMED, the Laboratory, and the U.S. Department of Energy.

The SCI-2 core hole was drilled to obtain core samples of hydrostratigraphic units beneath Sandia Canyon in order to investigate contaminant distributions in rocks of the vadose zone and water quality of perched water, if present. Because intermediate depth perched groundwater was found during drilling, an intermediate well was installed to monitor the temporal trends in water quality and water levels of perched water. Drilling and completion of the deeper regional aquifer well R-43 on the same drill pad were carried out according to the drilling plan.

The SCI-2 core hole was drilled using sonic coring/drilling and conventional air-coring methods (when the former method became untenable). The total depth (TD) of the core hole was 890.0 ft below ground surface (bgs). Little potable water was utilized during drilling, and the addition of foam was very minimal during the coring phase of drilling. The R-43 borehole was drilled using dual-rotary air-drilling methods to a TD of 1006 ft bgs. Foam-assisted drilling was used only in the vadose zone; no drilling-fluid additives other than small amounts of potable water and the air were used within the regional aquifer. Additive-free drilling provides minimal impacts to the groundwater and aquifer materials. The R-43 borehole was successfully completed to TD using dual-rotary casing-advance drilling methods.

Well SCI-2 was completed as a single-screen intermediate depth well within a perched zone in the lower part of the Cerros del Rio basalt. A monitoring well was installed with a screened interval between 548.0 and 568.0 ft bgs. Well R-43 was completed with two well screens in the regional groundwater system: both within the Miocene riverine deposits. The upper screened interval was from 903.9 to 924.6 ft bgs and the lower screened interval was from 969.1 to 979.1 ft bgs.

Wells SCI-2 and R-43 are intended to further define the nature and extent of contamination and address key uncertainties in the conceptual model for contaminant fate and transport of contaminants, with particular emphasis on chromium beneath Sandia Canyon. A dedicated pneumatic Bennett pump sampling system was installed in SCI-2. A dedicated Baski two-zone sampling system has been designed for R-43; however, it has not yet been installed. A temporary inflatable packer, separating the two screens in R-43, is presently in place until the Baski system is installed. Groundwater sampling of both wells will be performed as part of the facility-wide groundwater-monitoring program.

The wells were completed in accordance with an NMED-approved well design, and both wells were thoroughly developed and met target water-quality parameters. Hydrogeologic testing indicated that monitoring well R-43 is productive and will perform effectively to meet the planned objectives.

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Acronyms and Abbreviations

µS/cm	microsiemen per centimeter
amsl	above mean sea level
ASTM	American Society for Testing and Materials
bgs	below ground surface
Consent Order	Compliance Order on Consent
DI	deionized
DO	dissolved oxygen
EES-14	Environmental and Earth Sciences Group
ENV-MAQ	Environmental Stewardship–Meterology and Air Quality
EP	Environmental Programs
ICPOES	inductively coupled (argon) plasma optical emissison spectroscopy
ICPMS	inductively coupled (argon) mass spectrometry
I.D.	inside diameter
IDW	investigation-derived waste
IWD	integrated work document
LANL	Los Alamos National Laboratory
mV	millivolt
NMED	New Mexico Environment Department
NMSW	New Mexico special waste
NTU	nephelometric turbidity unit
O.D.	outside diameter
ORP	oxidation-reduction potential
PVC	polyvinyl chloride
RCT	radiation control technician
SMO	Sample Management Office
SOP	standard operating procedure
SWL	static water level
TA	technical area
TD	total depth
TOC	total organic carbon
U	undetected
WCSF	waste characterization strategy form

1.0 INTRODUCTION

This completion report summarizes the site preparation, drilling, well construction, well development, aquifer testing, and related activities for groundwater-monitoring wells R-43 and SCI-2 and was written in accordance with the requirements in Section IV.A.3.e.iv of the March 1, 2005, Compliance Order on Consent (the Consent Order). Core hole and well SCI-2 and well R-43 were drilled and completed from June 2008 to October 2008 at Los Alamos National Laboratory (LANL or the Laboratory) for the Environmental Programs (EP) Water Stewardship Project.

The R-43/SCI-2 project site is located in Sandia Canyon in an area west of well R-11 (Figure 1.0-1). The purpose of the R-43/SCI-2 monitoring wells is to achieve specific data quality objectives consistent with the Groundwater Protection Program for the Laboratory and Consent Order, in addition to the New Mexico Environment Department- (NMED-) approved “Work Plan for Geochemical Characterization and Drilling for Fate and Transport of Contaminants Originating in Sandia Canyon” (LANL 2007, 099607). The SCI-2 core hole was drilled to obtain core samples of the hydrostratigraphic units beneath Sandia Canyon to investigate the stratigraphy and geochemistry of these units. Specifically, wells R-43 and SCI-2 were installed to help further define the nature and extent of contamination and to address key uncertainties in the conceptual model for contaminant fate and transport of contaminants, with particular emphasis on chromium, beneath Sandia Canyon. The R-43 and SCI-2 wells are located on the same drill pad and are approximately 75 ft apart.

The primary objective of drilling R-43 was to define the nature and extent of contamination in the regional aquifer, with special emphasis on chromium contamination. Both wells will provide hydrogeologic and groundwater-quality data. Proximal upgradient positions make these two wells critical sampling points for understanding contaminant movement beneath Sandia Canyon.

The SCI-2 core hole was successfully drilled to a total depth (TD) of 890.0 ft below ground surface (bgs). A monitoring well was installed with a screened interval between 548.0 and 568.0 ft bgs. The depth to water after well installation and well development was 514.3 ft bgs. Continuous core samples were collected from the ground surface to 890 ft bgs, with the exception of poor recovery zones and pulverization of core through the Bandelier Tuff and into the upper Puye Formation by the sonic drilling method used in that interval. The R-43 borehole was drilled to a TD of 1006 ft bgs, and a dual-screen monitoring well was installed with an upper screened interval from 903.9 to 924.6 ft bgs and a lower screened interval from 969.1 to 979.1 ft bgs. The depth to water after well installation and well development was 892.9 ft bgs. Cuttings samples were collected at 5-ft intervals in the borehole from 620 ft bgs to TD.

Postinstallation activities at both locations included well development, aquifer testing (R-43 only), surface completion, dedicated sampling system installation (the Baski system has not yet been installed at R-43), and geodetic surveying. Ongoing activities include waste management and site restoration.

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 all activities associated with the R-43/SCI-2 project, as well as supporting figures, tables, and appendixes.

2.0 PRELIMINARY ACTIVITIES

Preliminary activities included preparing administrative planning documents and preparing the drill sites and drill pads. All preparatory activities were completed in accordance with Laboratory policies and procedures.

2.1 Administrative Preparation

The following documents helped guide the implementation of the scope of work for these wells: "Work Plan for Geochemical Characterization and Drilling for Fate and Transport of Contaminants Originating in Sandia Canyon" (LANL 2007, 099607), "Integrated Work Document for Regional and Intermediate Aquifer Well Drilling" (LANL 2007, 100972), "Storm Water Pollution Prevention Plan Addendum" (LANL 2006, 092600), and "Waste Characterization Strategy Form (WCSF) Chromium Wells (R-42, SCI-2/R-43) and Corehole Installation" (LANL 2008, 101914).

2.2 Site Preparation

Both boreholes were installed on the same drill pad. Site preparation was performed between June 10 and 17, 2008, and included clearing and grading the drill pad and access road; excavating and lining a cuttings containment pit; and installing berms, silt fencing, and straw waddles to control stormwater run-on/runoff and prevent erosion. The drill pad dimensions were approximately 200 ft × 100 ft and the pad is covered with base course. The access road is 300 ft long and is also covered with base course. The joint cuttings pit for SCI-2 and R-43 measured approximately 50-ft × 30-ft × 8-ft average depth. Radiation control technicians (RCTs) from the Radiation Protection Group-1 performed radiological screening of the site and construction equipment as required.

Office and supply trailers, generators, and general field equipment were moved on-site after mobilization of drilling equipment. Potable water for drilling was trucked to the site by the drilling subcontractor from a Los Alamos County fire hydrant located outside of the municipal landfill on East Jemez Road. Safety barriers and signs were installed around the borehole-cuttings containment pit and along the perimeter of the work area.

3.0 DRILLING ACTIVITIES

This section describes the drilling strategy and provides a chronological summary of field activities conducted at SCI-2 and R-43.

3.1 Drilling Approach

SCI-2

The drilling/coring of SCI-2 was accomplished by using sonic and conventional coring methods. A convertible rotosonic drill rig, specifically designed for continuous coring with either rotary or sonic methods, was utilized for all drilling at SCI-2. Sonic coring proceeded from the surface to a depth of 420 ft bgs, just below the top of the Cerros del Rio basalt. At that depth, the rig was converted to run conventional core tooling by removing the sonic head and installing a pass-through rotary coring head to achieve the higher rotational speed required to core consolidated rock units. The sonic vibration hydraulic circuit of the rig was disabled during conventional coring. The sonic head was also used for freeing stuck core pipe and casing later during casing retraction. Conventional coring proceeded through the basalt into the lower Puye Formation and was terminated upon refusal in Miocene sediments at 890 ft bgs.

Minimal drilling fluids were used during drilling at SCI-2. Fluids used included municipal water and Baroid AQF-2 foaming agent. On one occasion, Baroid QUIK-GEL was used to assist in lubricating and loosening a stuck drill rod. The fluids helped cool the bit and aided with coring and circulation. A cumulative total of drilling fluids introduced into the borehole and those recovered are presented in Table 3.1-1.

R-43

The drilling methodology and selection of equipment and drill-casing sizes were designed to retain the ability to case off perched groundwater and reach TD with sufficiently sized casing to meet the required 2-in. minimum thickness of the annular filter pack around a 5.56-in.-outside diameter (O,D.) well. Further, it was anticipated that drill casing or cementing would be used to isolate the perched zone encountered at SCI-2 to avoid commingling perched groundwater with the regional aquifer.

Dual-rotary air-drilling techniques and a Foremost DR-24HD drill rig were used to drill the R-43 borehole. Dual-rotary drilling has the advantage of simultaneously advancing and casing the borehole. The Foremost DR-24HD drill rig used was equipped with conventional direct circulation drilling rods, tricone bits, downhole hammer bits, a deck-mounted 900 ft^3/min air compressor, and miscellaneous drilling equipment. On-site equipment included two auxiliary Sullair 1150 ft^3/min trailer-mounted air compressors. Two sizes of flush-welded mild carbon-steel casing (16-in. and 12-in.) were used to complete the R-43 borehole. The 16-in. casing was used for drilling from ground surface to the top of the Cerros del Rio basalt. The 12-in. casing was utilized when unstable conditions were encountered after open-hole drilling in the lower Puye Formation. Dual-rotary drilling methods with 12-in. casing continued to TD in Santa Fe Group sediments.

Drilling fluids used in the vadose zone included filtered compressed air, municipal water, and Baroid AQF-2 foaming agent. Use of drilling fluids was terminated approximately 100 ft above the predicted water table. No additives other than municipal water were used for drilling within the regional aquifer. Table 3.1-1 presents a cumulative total of drilling fluids introduced into the borehole and those recovered.

3.2 Chronological Drilling Activities

SCI-2

Drilling equipment and supplies were mobilized to the site between June 18 and 19, 2008. On June 20, 2008, the SCI-2 core hole was initiated with sonic drilling/coring methods using flush-threaded 8-in. casing and a 7-in. core barrel. The 8-in. casing was advanced to 100 ft bgs before switching to 7-in. casing and a 6-in. core barrel. Rotosonic drilling methods rely on core barrel returns as a means of circulation and also typically rely on several sizes of casing to reach intended drilling depths. The 8-in. casing was advanced as far as the driller felt practical to retrieve the casing. An attempt was made to advance the borehole in an open-hole fashion to 115 ft bgs before switching to the 7-in. casing, but the hole did not reliably stay open in the Otowi Member of the Bandelier Tuff.

Sonic coring progressed smoothly from June 20 to June 23, 2008, to 367 ft bgs when all available 7-in. casing was installed in the borehole. The 6-in. core barrel was replaced on June 22, 2008, at 240 ft bgs after showing signs of heat stress and erosion. Minor wetness in the core was observed at 327 to 328 ft bgs in the Guaje Pumice Bed.

Sonic coring recommenced on June 28, 2008, after a scheduled crew break. At the end of the day, coring had slowed significantly in the Cerros del Rio basalt, reaching a maximum depth of 420 ft bgs. Delays in obtaining more 7-in. casing prevented advance of the casing to 415 ft bgs until July 1, 2008. Multiple water-level measurements were taken between June 28 and July 1, 2008, to verify that no standing water was accumulating on or near the top of the Cerros del Rio basalt. A bentonite chip seal was installed and hydrated to seal the 7-in. casing at the top of the Cerros del Rio basalt.

After a scheduled crew break, the rig was changed over to run conventional wireline retrievable core tooling on July 8, 2008. This included thoroughly decontaminating the core tooling and conducting necessary rig modifications. Coring began again on July 10, 2008, and reached a depth of 421 ft bgs with a PQ-size core barrel and HWT casing (85-mm core and 114-mm casing). Because problems occurred while the core was retrieved, the driller had to fabricate an HWT-size diverter for the rig, remove the PQ core barrel, put a shoe on the HWT pipe, and switch to smaller HQ-sized core tooling (63.5-mm core and 88.9-mm casing) for further drilling on July 11, 2008. Also on that day, light plants were installed on the drill site and 24-h operations began.

Incompatibilities with parts of the HQ coring system caused several days of problems that were finally resolved on July 15, 2008. A faulty hydraulic pump on the rig was also replaced. Coring progressed relatively smoothly through the Cerro del Rio basalt on July 16 and 17, 2008. Frequent stops to circulate air-only showed no evidence of groundwater. Samples of recovered core were delivered to the Environmental Earth Sciences Group (EES-14) laboratory for metals, tritium, and physical properties analyses. Core recoveries were typically 100% in the consolidated Cerros del Rio basalt. Circulation was noted as being poor to nonexistent while this unit was drilled. The discharge pipe from the top of the hole returned air, but no cuttings or water were observed in the discharge. Whether this was caused by the fractured nature of the basalt or by the unusual combination of varying sizes of casing and core pipe was not determined.

On July 18, 2008, the Cerros del Rio basalt and lower Puye Formation contact was reached at approximately 630 ft bgs. Core recovery was poor in the vicinity of the contact to 655 ft bgs and remained variable through 825.5 ft bgs. In the cores retrieved, there was no indication of saturated conditions through this interval.

On July 19, 2008, the driller suspected groundwater saturation occurring in the 880- to 890-ft bgs interval as the core pipe became difficult to rotate and circulation diminished entirely. An empty core sleeve was retrieved; with difficulty, the core tooling retracted to 804.5 ft bgs. An accumulation of damp or saturated cuttings in the annulus most likely caused the drill string to become stuck in the hole. Unsuccessful attempts were made on July 20, 2008, to pull the tools back, despite the addition of approximately 450 gal. of potable water and Baroid QUIK-GEL to lubricate the tools and help lift cuttings out of the annulus.

On July 25, 2008, after a scheduled crew break, smaller NQ core tooling—47.6-mm core and 69.9-mm casing—were delivered to the site. An HQ-to-NQ diverter was fabricated and the HQ core pipe was cut off at the surface. Additionally, the lighting for nighttime operations was removed from the site. From July 26 to 28, 2008, the NQ coring tools were run into the borehole; the internal HQ coring landing ring, stabilizer, and bit were milled off (by using the NQ tools); the borehole was redrilled to a depth of 875.5 ft bgs. On July 28, 2008, the driller reported that cuttings were accumulating uphole of the drilled-out HQ core barrel. Because of limited circulation, deeper drilling with air-only methods was not advised without taking measures to improve circulation (i.e., introducing drilling fluids). The decision was made to terminate coring at SCI-2 due to limitations of the equipment. An attempt to run Laboratory downhole video equipment through the HQ pipe that day failed because foam and sediment accumulated on the sides of the wall, which covered the camera and resulted in poor visibility.

Natural gamma logging with the Laboratory logging unit confirmed the location of the HQ core barrel from 798 to 805 ft bgs on July 30, 2008. The HQ core barrel assembly was cut off in an effort to retrieve as much of the HQ tool string as possible. A cut was successfully made in the HQ casing/rods at 782 ft bgs by using the NQ core pipe to run an internal casing cutter. Unfortunately, the cut HQ pipe would not budge.

Bentonite chips were installed in the borehole with a tremie pipe through the 850- to 875-ft bgs interval on July 31, 2008, and a second, shallower cut was made at 659.5 ft bgs in the HQ pipe (approximately at the Cerros del Rio basalt, lower Puye Formation contact). The HQ pipe was then removed from the hole only after switching out the coring drill head with the sonic drill head, which allowed pipe string vibration. A total of 145.5 ft of HQ casing/rods and core barrel remained in the borehole.

On August 1, Laboratory personnel ran video, induction, and gamma tools in the core hole. The video log showed water was entering the borehole at 509.4, 546, and 564.5 ft bgs at estimated rates varying from 0.25 to 1 gal./min. The water level in the hole was measured at 590.0 ft bgs. The cut-off HQ casing was observed at 659.5 ft bgs. Several water samples were obtained by bailing that day.

Initial pullback and reseating of the HWT casing using the sonic head were completed on August 2, 2008. The HWT casing was loosened and reseated to ensure it was mobile before the sonic rig was moved off the site; the goal was to keep the casing in place for well construction. The outermost 8-in. casing was removed. The 7-in. sonic casing parted at a threaded joint at 36 ft bgs while being retracted. The 7-in. casing and the HWT pipe were left in the borehole and site demobilization started. The HWT pipe was later removed during well construction. Moving and RCT screening of the drilling rig and drilling equipment concluded on August 4, 2008. A water-level measurement of 561.23 ft bgs was also recorded.

The field crew worked two shifts 12 h/d, 7 d/wk during and after sonic coring activities. On July 25, 2008, the crew returned to a single 12-h shift. Operations had numerous lightning delays during the coring. Some technical delays were incurred because of the complex nature of coring at depth in variably fractured, hard, and semiconsolidated geologic formations. Minor delays due to coring equipment incompatibilities and shipping delays also impeded progress.

R-43

Rotary drilling equipment and supplies were mobilized to the R-43 drill site from August 9 to 12, 2008, several days after the coring rig was moved off of the SCI-2 location. The R-43 borehole was initiated with dual-rotary methods using 16-in. casing and a 15-in. conventional hammer bit on August 12, 2008. The 16-in. casing was advanced through the alluvium, the Otowi Member of the Bandelier Tuff, and the Upper Puye Formation and landed at 417.7 ft bgs in the top of the Cerros del Rio basalt on August 18, 2008. Drilling continued below the top of the Cerros del Rio basalt using open-hole drilling methods with the 15-in. hammer bit.

Drilling operations proceeded without incident through the Cerros del Rio basalt to a depth of 635 ft bgs—2 ft into the lower Puye Formation—from August 20 to 21, 2008. On August 22, 2008, a minor amount of groundwater was detected in the borehole and was air-lifted to the surface; a sample was taken for analysis. After sampling, an additional 5 ft was drilled before the drill string was pulled from the borehole for geophysical logging. Laboratory personnel conducted natural gamma, induction, and video logging in the open portion of the borehole at a drilling depth of 640 ft bgs.

On August 23, 2008, the 408.3 to 640 ft bgs open-hole interval was cemented to seal the perched intermediate groundwater zone. Redrilling the cemented interval with open-hole drilling methods and the 15-in. hammer bit commenced on August 24. Cuttings from the cemented interval were redirected into two on-site rolloff bins rather than into the cuttings pit.

Open-hole drilling concluded on August 25, 2008, after reaching a depth of 795 ft bgs in the lower Puye sediments. Because of unstable formation conditions, the decision was made to switch over to dual-rotary methods using 12-in. casing beyond 795 ft bgs.

Before advancing a 12-in. casing string to TD, the 16-in. casing shoe was cut on August 27, 2008, at 300.0 ft bgs. The same day, Laboratory personnel also conducted natural gamma, induction, and video logging. Video logging confirmed effective sealing of perched water in the Cerros del Rio basalt interval by cement. Hanging and welding a 12-in. casing string commenced on September 2 and concluded on September 6, 2008. A bentonite chip seal was installed and hydrated at 790.2 ft bgs before the 12-in. casing was lowered to the bottom of the hole.

Dual-rotary drilling with 12-in. casing and an 11 7/8-in. tricone bit started on September 7, 2008. Only air and minor amounts of potable water were utilized while drilling below 795 ft bgs. On September 9, 2008, suspected regional groundwater samples were collected by air-lifting through the tools at 895 and 915 ft bgs; four additional water samples were taken at 955, 975, 993, and 1006 ft bgs on September 10, 2008. The last sample depth at 1006 ft bgs marked the R-43 borehole's TD—approximately 100 ft into the regional aquifer. Several water-level measurements on September 11, 2008, indicated a relatively stable water level at 893.8 ft bgs.

On September 12, 2008, Laboratory personnel logged the lower cased section of the borehole with a natural gamma tool while plans were made to cut off the 12-in. casing shoe. On September 13, 2008, the 12-in. casing was successfully cut at 997 ft bgs, and the dual-rotary drill rig was moved off the borehole, making way for well construction activities.

The field crew worked one 12-h shift per day, 7 d/wk. Operations sustained occasional weather delays during drilling due to lightning. Only minor mechanical delays impeded progress.

4.0 SAMPLING ACTIVITIES

This section describes the cuttings and groundwater sampling activities at SCI-2 and R-43. All sampling activities were conducted in accordance with all applicable quality procedures.

4.1 Core and Cuttings Sampling

SCI-2

The SCI-2 borehole was cored continuously from surface to TD (890.0 ft bgs). Rotosonic methods were used to a depth of 419.5 ft bgs—approximately 20 ft into the Cerros del Rio basalt. The drill rig was converted to run conventional coring tools for the remainder of the core hole. Sonic core diameters were initially 7 in. but were downsized to 6 in. at 115 ft bgs and remained so to 419.5 ft bgs. After initiating conventional coring, PQ-size core (85 mm) was almost immediately replaced by slightly smaller HQ-size core (63.5 mm) at 421 ft bgs and carried on until TD. Very little potable water was used while sonic coring, and only moderate water volumes with small volumes of AQF-2 foaming agent were used during the deeper conventional coring. Core recovery was typically 100% through the Bandelier Tuff and upper Puye Formation, but the sonic coring system disaggregated the core samples and they were not recovered intact. Core recoveries using conventional methods were typically 100% through the bottom of the Cerros del Rio basalt but were generally poor in the lower Puye Formation interval, consistent with the semiconsolidated nature of that unit. In the deeper pumiceous sediments, recoveries improved.

A total of 28 samples were selected from the recovered core. Table 4.1-1 presents a summary of all core samples collected for analysis during coring/drilling of SCI-2. Above the Cerros del Rio basalt, analyses were only for moisture content. Analytical samples were selected from significant geologic zones consistent with the drill plan and were typically 30 ft or less between samples from the top of the Cerros del Rio basalt (poor lower Puye Formation recoveries caused the exception). Beginning at the Guaje Pumice Bed to TD, samples were analyzed for moisture anions (including hexavalent chromium, uranium, molybdenum, zinc, phosphorous, and boron), total organic compound (TOC), tritium, U.S. Environmental Protection Agency 3050 leach chromium, and nitrogen isotopes.

Core were placed into core boxes immediately upon retrieval. The core boxes were marked with the SCI-2 core hole identification number, core depths corresponding to each piece of core, and percent recovery for the interval noted. Sections of core chosen for analysis were placed in appropriate containers and transferred to both the EES-14 laboratory and to the Sample Management Office (SMO) for analysis.

Sections of core removed for sampling were identified in the core boxes with a spacer to indicate missing sections taken for laboratory analyses. All remaining core samples were archived. The borehole lithologic logs for SCI-2 and R-43 are presented in Appendix A.

R-43

Because of their proximity to the fully characterized SCI-2 core hole, cuttings samples were collected at the R-43 borehole only in the intervals from 620 ft bgs to the TD of 1006 ft bgs. Approximately 500 mL of bulk cuttings was collected every 5 ft from the discharge hose, sealed in resealable plastic bags, labeled, and archived in core boxes. Splits of the bulk cuttings were sieved (>#10 and >#35 mesh) and placed in chip trays along with unsieved (whole rock) cuttings. RCTs screened all cuttings before they were removed from the site.

Drilling and sample collection methods used at R-43 did not retain a majority of the fine fraction (silt and clay) of the drill cuttings, and much of the fine material throughout the borehole stratigraphy was lost. The velocity of compressed air and water required for circulations made catching samples difficult, and fines were selectively lost during sample collection. Site geologists manually collected samples with a wire mesh basket directly from the discharge hose, and discharge velocities commonly forced the fine fraction of sample through the basket. Recovery of the coarser fraction of the cuttings samples was excellent in nearly 100% of the borehole. The borehole lithologic log for R-43 is presented in Appendix A.

4.2 Water Sampling

SCI-2

One perched groundwater sample (590 ft bgs) was collected during drilling operations by running a bailer on a wireline. Six perched groundwater samples (549–599, 549–599, 549–599, 547–567, 547–567, and 547–567 ft bgs) were collected during well development activities by pumping water from a Bennett pump set in 2-in. polyvinyl chloride (PVC) well casing. The 549–599 ft samples were collected before any annular fill was placed around the PVC well casing. The 547–567 ft samples were collected from the completed well.

All groundwater samples were submitted to the EES-14 groundwater chemistry laboratory for analysis of anions and TOC. Sampling documentation and containers were provided by the Laboratory and processed through the SMO. Groundwater analytical results and details of groundwater chemistry at SCI-2 are presented in Appendix B. Table 4.2-1 summarizes all groundwater samples collected during drilling and well development activities.

Groundwater characterization samples were collected from the completed well in accordance with the Consent Order. The samples were analyzed for the full suite of constituents, including radioactive elements; metals/cations; general inorganic chemicals; volatile and semivolatile organic compounds; and stable isotopes of hydrogen, nitrogen, and oxygen. These groundwater analytical results will be reported in the annual update to the “Interim Facility-Wide Groundwater Monitoring Plan.”

R-43

Groundwater-screening samples were collected from the drilling discharge hose at approximate 20-ft intervals from the top of regional aquifer to the TD of 1006 ft bgs in the R-43 borehole. Typically upon reaching the bottom of a 20-ft run of casing, the driller would stop water circulation (if injecting water) and circulate air to clean out the borehole. As the discharge cleared, a water sample was collected directly from the discharge hose. Not all depth intervals below the top of the regional groundwater table could be captured at the end of each casing run, and as a result some water samples were collected upon start-up of the next casing run after the borehole equilibrated.

One perched groundwater sample (630–635 ft bgs) was collected during drilling operations by air-lifting a water sample through the drill string. Six regional groundwater samples (894.5–895, 914.5–915 , 954.5–955, 974.5–975, 992.5–993, and 1005–1006 ft bgs) were collected during drilling operations by air-lifting water samples through the drill string.

Regional groundwater samples were also collected at regular intervals (approximately one sample per 4 h) during well development and aquifer testing. The groundwater samples were collected from the discharge port of the submersible development pump and were submitted for analyses.

All groundwater samples were submitted to the EES-14 groundwater chemistry laboratory for analysis of anions and TOC. Sampling documentation and containers were provided by the Laboratory and processed through the SMO. Groundwater analytical results and details of groundwater chemistry at R-43 are presented in Appendix B. Table 4.2-1 summarizes all groundwater samples collected during drilling and well development activities.

Groundwater characterization samples were collected from the completed well in accordance with the Consent Order. The samples were analyzed for the full suite of constituents, including radioactive elements; metals/cations; general inorganic chemicals; volatile and semivolatile organic compounds; and stable isotopes of hydrogen, nitrogen, and oxygen. These groundwater analytical results will be reported in the annual update to the “Interim Facility-Wide Groundwater Monitoring Plan.”

5.0 GEOLOGY AND HYDROGEOLOGY

A brief description of the geologic and hydrogeologic features encountered at SCI-2 and R-43 is presented below. The Laboratory’s geology task leader and site geologists examined core, cuttings, and geophysical logs to determine geologic contacts. Drilling observations, video logging, water-level measurements, and geophysical logs were used to characterize groundwater occurrences encountered at both locations.

5.1 Stratigraphy

The stratigraphy for the SCI-2 core hole and R-43 borehole are presented below in order of youngest to oldest geologic units. Lithologic descriptions are based on core and samples of discharged cuttings. Core, cuttings, and borehole geophysical logs were used to identify geologic contacts. Figures 5.1-1 and 5.1-2 illustrate the stratigraphy at SCI-2 and R-43, respectively. Appendix A presents a detailed lithologic log for the SCI-2 core hole and a detailed lithologic log of deeper strata (from 620 ft to TD), based on R-43 drill cuttings. These two lithologic logs are presently separately in Appendix A.

SCI-2

Quaternary Alluvium, Qal (0–37 ft bgs)

Quaternary alluvium, consisting of unconsolidated silty sand to sandy silt with pebbles and gravels of tuffaceous sediments, was encountered from 0 to 37 ft bgs. No evidence of alluvial groundwater was observed.

Tshirege Member, Unit 1g of the Bandelier Tuff, Qbt1g (37–77 ft bgs)

Unit 1g of the Tsirege Member of the Bandelier Tuff occurs from 37 to 77 ft bgs. Unit 1g of the Tshirege Member is a white to reddish yellow, poorly welded ash-flow tuff. It is pumiceous and lithic-poor. Abundant phenocrysts of sanidine and quartz plus vitric pumice lapilli (up to 8 cm) are set in a matrix of glassy ash.

Cerro Toledo Inteval, Qct (77–111 ft bgs)

The Cerro Toledo interval is a mix of brown to reddish brown volcaniclastic and tuffaceous unconsolidated sediments. Poorly sorted fine to coarse sand and gravelly (small cobbles up to 7 cm) sand contains grains composed of subangular detrial quartz, sanidine, pumice, and dacite clasts.

Otowi Member of the Bandelier Tuff, Qbo (111–327 ft bgs)

The Otowi Member of the Bandelier Tuff is present from 111 to 327 ft bgs. The Otowi Member is a pale red to pinkish gray glassy, lithic-rich, pumiceous, poorly welded ash-flow tuff. It contains abundant white to orange-brown pumice lapilli (up to 2 cm), dacite and andesite lithics (up to 3 cm), plus quartz and sanidine phenocrysts in a matrix of fine glassy volcanic ash.

Guaje Pumice Bed of the Otowi Member of the Bandelier Tuff, Qbog (327–350 ft bgs)

The Guaje Pumice Bed is present from 327 to 350 ft bgs. The white pumice fall is largely composed of pumice fragments (up to 23 mm), with minor glassy ash and small volcanic (dacite, 1–3 mm) fragments locally present.

Upper Puye Formation, Tpf (350–396 ft bgs)

The reddish brown to black upper Puye Formation consists of siltstone, sandstone, and fine- to coarse-conglomeratic sandstone from 350 to 396 ft bgs. Clasts (up to 35 mm) are predominantly dacite and rhyolite, with minor small pumice fragments. Below 386 ft bgs, weathered angular basalt fragments increase in frequency and size with depth. The black cobble- and boulder-sized vesicular basalt clasts are contained in a silty matrix.

Cerros del Rio Basalt, Tb 4 (396–629.2 ft bgs)

Cerros del Rio basalt from 396 to 629.2 ft bgs consists of multiple lava flows of vesicular to massive porphyritic basalt with an aphanitic groundmass. Trace to minor olivine and plagioclase phenocrysts and local clay coatings and clay-filled vesicles are evident. Basalt ranges from dark to medium gray to dark reddish gray.

Lower Puye Formation, Tpf (629.2–827 ft bgs)

The reddish brown to gray lower Puye Formation consists of poorly sorted volcaniclastic sediments with clay, silt, sand, gravels, and cobbles/boulders. Gravel, cobbles, and boulders (from core) are predominantly dacitic in composition; trace pumice is also present. The degree of cementation is variable.

Micoene Pumiceous Deposits Tjfp (827–890 ft bgs)

Miocene pumice-rich sedimentary deposits are present from 827 ft to TD at 890 ft bgs. These sediments consist of light brown to reddish yellow, fine-grained pumiceous and volcaniclastic detritus. The sediments range from gravels with silt and sand to gravelly silt and sand with clay. The gravel and sand component consists primarily of rhyolite pumice fragments and rhyolite and dacite lava clasts. The interval from 887.1 to 890 ft is a clast-supported primary pumice fall.

R-43

Quaternary Alluvium, Qal (0–44 ft bgs)

Quaternary alluvium, consisting of unconsolidated silty sand to sandy silt with pebbles and gravels of tuffaceous sediments, was encountered from 0 to 40 ft bgs. No evidence of alluvial groundwater was observed.

Tshirege Member, Unit 1g of the Bandelier Tuff, Qbt1g (44–88 ft bgs)

Unit 1g of the Tshirege Member of the Bandelier Tuff occurs from 40 to 88 ft bgs. Unit 1g of the Tshirege Member is a white to reddish yellow poorly welded ash-flow tuff. It is pumiceous and lithic-poor. Abundant phenocrysts of sanidine and quartz plus vitric pumice lapilli (up to 8 cm) are set in a matrix of glassy ash.

Cerro Toledo Inteval, Qct (88–112 ft bgs)

The Cerro Toledo interval is a mix of brown to reddish brown volcaniclastic and tuffaceous unconsolidated sediments. Poorly sorted fine to coarse sand and gravelly (small cobbles up to 7 cm) sand grains are composed of subangular detrial quartz, sanidine, pumice, and dacite clasts.

Otowi Member of the Bandelier Tuff, Qbo (112–338 ft bgs)

The Otowi Member of the Bandelier Tuff is present from 112to 327 ft bgs. The Otowi Member is a pale red to pinkish gray, glassy, lithic-rich, pumiceous, poorly welded ash-flow tuff. It contains abundant white to orange-brown pumice lapilli (up to 2 cm), dacite and andesite lithics (up to 3 cm), plus quartz and sanidine phenocrysts in a matrix of fine glassy volcanic ash.

Guaje Pumice Bed of the Otowi Member of the Bandelier Tuff, Qbog (338–358 ft bgs)

The Guaje Pumice Bed is present from 338 to 358 ft bgs. The white air-fall pumice bed is largely composed of pumice fragments (up to 23 mm), with minor glassy ash and small volcanic (dacite, 1–3 mm) fragments locally present.

Upper Puye Formation, Tpf (358–394 ft bgs)

The reddish brown to black upper Puye Formation consists of siltstone, sandstone, and fine- to coase-conglomeratic sandstone deposits. Clasts (up to 35 mm) are predominantly dacite and rhyolite, with minor small pumice fragments. Weathered angular basalt fragments increase in frequency and size with depth.

Cerros del Rio Basalt, Tb 4 (394–630 ft bgs)

Cerros del Rio basalt from 394 to 630 ft bgs consists of multiple lava flows of vesicular to massive porphyritic basalt with an aphanitic groundmass. Trace to minor olivine and plagioclase phenocrysts and local clay coatings and clay-filled vesicles are evident. Basalt ranges from light to medium gray to dark reddish gray.

Lower Puye Formation, Tpf (630–864 ft bgs)

The pinkish white to white lower Puye Formation consists of poorly sorted volcaniclastic sediments with clay, silt, sand, gravels, and cobbles/boulders. Gravel, cobbles, and boulders are predominantly dacitic in composition; trace pumice is also present. The degree of cementation is variable.

Miocene Pumiceous Deposits, Tjfp (836–905 ft bgs)

Miocene pumice-rich sedimentary deposits are present from 836 to 905 ft bgs and consists of pale yellowish tan to yellowish brown, fine-grained pumiceous, volcaniclastic sediments ranging from gravels with silt and sand to gravelly silt and sand with clay. The gravel and sand component consists primarily of pumice fragments and rhyolite and dacite lava clasts.

Santa Fe Group Undivided, Tsfu (905–1006 ft bgs)

Undivided Santa Fe Group deposits are present from 905 ft to TD at 1006 ft bgs and consists of pinkish tan pumiceous, volcaniclastic sediments with variably 1%–20% of Precambrian quartzite and granite fragments. Sediments range from gravels with silt and sand to gravelly silt and sand with clay. The gravel and sand component consists primarily of volcanic rocks (dacite and ryolite), pumice fragments, fine- to medium-grained sandstone fragments, with minor Precambrian quartzite and granites.

5.2 Groundwater

SCI-2

Shortly after the lower portion of the borehole was abandoned, intermediate perched groundwater was detected at SCI-2 in the lower part of the Cerros del Rio basalt during video logging on August 1, 2008, at approximately 509.4, 546, and 564.5 ft bgs at estimated rates varying from 0.25 to 1 gal./min. A static water level (SWL) of 590.0 ft bgs was measured that day. On August 4, 2008, a water-level measurement of 561.23 ft bgs was measured in the borehole. Groundwater-screening samples (section 4.2) were collected from the core hole and during well development. After well installation and development, the SWL was measured at 531.4 ft bgs. No aquifer testing was performed at SCI-2 because of the small diameter of the well, the depth to water, and lack of available pump options. Appendix B discusses groundwater chemistry.

R-43

Intermediate depth perched ground water was detected during drilling at 635 ft bgs on August 22, 2008. A groundwater-screening sample was collected that day before the Cerros del Rio basalt was cemented and drilling proceeded.

Regional groundwater was first recognized at R-43 during drilling at approximately 895 ft bgs in Miocene pumiceous sediments on September 9, 2008. An SWL of 893.85 ft bgs was measured on September 11, 2008. A total of six groundwater-screening samples (section 4.2) were collected while drilling the 895–1006-ft bgs interval. After well installation and development, composite SWL for the two well screens was measured at 893.3 ft bgs. Appendix B discusses groundwater chemistry; Appendix C discusses aquifer testing data.

6.0 BOREHOLE LOGGING

Several video logs and a limited suite of open-hole and cased-hole geophysical logs were collected during the SCI-2/R-43 drilling project using Laboratory-owned equipment. A summary of video and geophysical logging runs is presented in Table 6.0-1. Selected video logs from both boreholes are presented on digital video discs in Appendix D.

No subcontract geophysical logging was performed during the R-43/SCI-2 project.

6.1 Video Logging

SCI-2

Video logs were run on August 1, 2008, in the SCI-2 core hole to check for the presence of perched groundwater in the Cerros del Rio basalt. Perched water was visually observed in the lower part of the Cerros del Rio basalt.

R-43

Video logging was conducted on August 27, 2008, in the R-43 open borehole after cementing off perched groundwater in the Cerros del Rio basalt. The video log showed that no groundwater was entering the borehole, verifying that the cement provided a good seal. On October 6 and 7, 2008, video logging was utilized for fishing operations to aid in the recovery of a 2-in. tremie pipe after it parted during well construction. An attempt was made on October 16 to visually inspect the top of cement inside the 16-in. casing but was unsuccessful because of opaque cement-laden water.

6.2 Geophysical Logging

Several natural gamma and induction tool logs were run in both SCI-2 and R-43 with the Laboratory's geophysical equipment. Details of the logging operations are presented in Table 6.0-1. Geophysical logs are presented on CD in Appendix E.

SCI-2

Three geophysical logging runs were conducted in the SCI-2 borehole. The first, an open-hole gamma, was run on July 30, 2008, and also confirmed the location of the stuck HQ core barrel. Gamma and induction tools were run on August 1, 2008. The scale of this induction log is questionable; however, the relative values are consistent with the hydrogeology observed. A third gamma log verified the top of the sand pack on September 2, 2008.

R-43

Routine natural gamma logs were run on August 27 and September 12, 2008, capturing the interval from surface to TD. Additionally, an induction log was also recorded in the open borehole from surface to 790 ft bgs on August 27.

7.0 WELL INSTALLATION

SCI-2 well casing and annular fill were installed between August 4, 2008, and September 2, 2008, while the R-43 well casing and annular fill were installed between September 14, 2008, and October 17, 2008.

7.1 Well Design

Both the SCI-2 and R-43 wells were designed in accordance with the Consent Order. NMED approved each well design before installation. The SCI-2 well was designed with a single screen to monitor intermediate depth perched groundwater within the lower portion of the Cerros del Rio basalt. See Appendix F for a discussion of SCI-2 screen-interval selection. The R-43 well was designed with two screens, both located in the upper portion of the regional aquifer. The dual-screen design serves multiple purposes. The screen near the top of the regional aquifer was placed to capture chromium that may percolate down from the elevated chromium-containing perched zone, as defined in the SCI-2. Because the upper screen is within a zone of silty sediments that have low transmissivity, it may not capture the high transmissivity interval. The second screen will provide information and characterization of vertical dispersion of contamination, if present.

7.2 Well Construction

SCI-2

The SCI-2 monitoring well was constructed of 2.0-in.-inside diameter (I.D.)/2.375-in.-O.D. schedule 40 flush-threaded PVC casing. The screened section utilized 0.020-in. slotted schedule 40 PVC well screen. The casing and screen were factory-cleaned and sealed in plastic before installation.

A 20-ft-screened interval was chosen for SCI-2, with screen set at 548.0 to 568.0 ft bgs. A 2-ft sump was placed below the screen. A Smeal work-over rig was used for all well construction and development activities. Figure 7.2-1 presents an as-built schematic showing construction details for the completed well.

Before the well casing was placed in the hole, the lower section of the core hole was abandoned to a depth of 580.1 ft bgs by using a mix of bentonite pellets and chips. The bentonite backfill material isolated the cut-off HQ-size core barrel and casing (659.5–805.0 ft bgs). Because of the depth and small diameter of the completion, the initial well construction plan called for using two rubber shale traps placed immediately above three sections of prepacked well screen. However, lowering the prepacked screens with the shale traps into the open portion of the core hole proved unworkable. On August 27, 2008, the construction plan was amended to allow the use of a standard PVC well screen (not prepack) with a placed sand filter pack and no shale traps.

After the well casing was assembled and lowered into the borehole, annular backfill materials were then installed. A filter pack of 10/20 silica sand was placed across the screened interval from 527.8 to 580.1 ft bgs. Above the filter pack, a bentonite pellet seal was installed from 418.0 to 527.8 ft bgs and a bentonite chip seal was set from 400.5 to 418.0 ft bgs. High-solids bentonite grout was placed from 46.2 to 400.5 ft bgs. The surface seal composed of 98% Portland cement and 2% bentonite was installed from ground surface to 46.2 ft bgs. Figure 7.2-1 depicts depths and volumes used in each interval. Table 7.2-1 details volumes of materials used during well construction for R-43 and SCI-2.

R-43

The R-43 monitoring well was constructed of 5.0-in.-I.D./5.56-in.-O.D. type A304 stainless-steel casing fabricated to American Society for Testing and Materials (ASTM) A312 standards. External couplings (also type A304 stainless steel fabricated to ASTM A312 standards) were used to connect individual casing and screen sections. The two screen sections were composed of two 10-ft lengths threaded together, forming the upper screen and one 10-ft length, forming lower screen. All screen material was 5.0-in.-I.D. rod-based 0.020-in. wire-wrapped. The coupled unions between threaded sections were approximately 0.6 ft long. The casing and screen were steam-cleaned on-site before installation. A 2-in.-I.D. steel threaded/coupled tremie pipe was used to deliver all backfill and annular fill materials during well construction.

Two screened intervals were chosen for R-43. The lower screen was set at 969.1 to 979.1 ft bgs, while the upper screen was set at 903.9 to 924.6 ft bgs. Blank 5-in. casing, 44.5 ft long, separates the two screens. Additionally, an 11.3-ft stainless-steel sump was placed below the lower well screen. A Semco work-over rig was used for all well construction and development activities. Figure 7.2-2 presents an as-built schematic showing construction details for the completed well.

After the well casing was assembled and installed in the borehole, the process of installing annular backfill materials was started. This activity had two components: installing materials and retracting the drill casing. While the level of annular fill came up, the drill casing was retracted and removed. As each section of drill casing was cut off the string, it had to be picked up and laid down. During this process, the well casing was suspended on a wireline in the borehole.

The interval from 1000.3 to 1006.0 ft bgs is formation slough. The lowermost bentonite seal was installed around the well sump from 985.1 to 1000.3 ft bgs. A lower filter pack of 10/20 silica sand was placed across the screened interval from 964.8 to 985.1 ft bgs. Above the lower filter pack, a transition sand collar of 20/40 silica sand was placed from 962.5 to 964.8 ft bgs. To prevent annular communication between the two screened intervals, a bentonite seal was installed from 928.4 to 962.5 ft bgs. Above this seal, the upper filter pack was placed from 899.9 to 928.4 ft bgs using 10/20 silica sand. Above the upper filter pack, a transition sand collar of 20/40 silica sand was placed from 897.6 to 899.9 ft bgs. A bentonite seal capping the upper transition sand collar was installed from 868.8 to 897.6 ft bgs. After installation of each primary filter pack, the work-over rig was used to surge the screened interval with a surge block to promote settling and compaction of the filter pack.

High-solids bentonite grout was installed from 629.8 to 868.8 ft bgs, and an uppermost bentonite seal was placed from 400.1 to 629.8 ft bgs. A surface seal composed of a mix of 97% Portland cement and 3% bentonite was installed from ground surface to 400.1 ft bgs. Figure 7.2-2 depicts depths and volumes used in each interval. Table 7.2-1 details volumes of materials used during well construction.

Overall, well construction proceeded smoothly and was only briefly interrupted when the tremie pipe parted and dropped in the borehole. The tremie was fully recovered several days later and construction progressed. The bentonite seal installed between the screen intervals consumed approximately 55% of the calculated volume of the annular space, suggesting the bentonite is mixed with borehole slough in this interval (see Figure 7.2-2). To address the unstable borehole conditions, the field crew retracted tenths of a foot at a time, but the formation continued to slough as the drill casing was retracted. Field reports indicate the worst of the sloughing formation was in the middle area between the screens, and the seal is best nearest the filter packs.

Also of note, 285 ft of 16-in. casing was left in place (1 to 286.2 ft bgs) when efforts to pull it failed. The 16-in. casing was retracted approximately 14 ft before it stopped moving. It is believed that the casing cutter used to cut off the drive shoe “belled” the bottom of the casing at the cut, and the lip created at the bottom of the casing loaded up with formation material. The 16 in. casing was overdrilled using 18-in. casing with a 21-in. drive shoe on January 11, 2009, to a depth of 54.2 ft bgs (approximately 10 ft below the base of the alluvium). The 18-in. casing was retracted and the annulus was sealed with cement grout containing 3% bentonite. Sealing the annular space consumed approximately 150% of the calculated volume of the annular space, indicating bentonite filled large washouts in the Bandelier Tuff.

8.0 POSTINSTALLATION ACTIVITIES

SCI-2

Following well installation at SCI-2, the well was developed; however, no aquifer testing was conducted. A Bennett pump and transducer were installed. The wellhead and surface pad were constructed and a geodetic survey of the wellhead was performed. Site restoration activities will be completed following the final disposition of contained drill cuttings and groundwater in accordance with the NMED-approved waste-decision trees.

R-43

Following well installation at R-43, the well was developed and aquifer pumping tests were conducted on both the upper and lower screened intervals. A Baski two-zone sampling system will be installed and the wellhead and surface pad will be constructed. A geodetic survey of the wellhead was performed. Site restoration activities will be completed following the final disposition of contained drill cuttings and groundwater in accordance with the NMED-approved waste-decision trees.

8.1 Well Development

SCI-2

Well development occurred between September 7 and October 9, 2008. A small amount (205 gal.) of purging (via Bennett pump) had taken place earlier on August 13–14, 2008, for sampling purposes. Bailing was briefly used for development purposes but because of the small (2-in.) I.D. of the well casing and screen, all subsequent development was done using a Bennett pump.

During the latter part of pump well development, turbidity, temperature, pH, dissolved oxygen (DO), oxidation-reduction potential (ORP), and specific conductance parameters were collected. In addition, water samples for TOC analysis were collected. The required values for TOC and turbidity by the end of well development were less than 2.0 ppm and less than 5 nephelometric turbidity units (NTUs), respectively. The TOC measurement at the end of SCI-2 well development was less than 0.5 ppm and the turbidity measurement was 0.6 NTU.

Approximately 2586 gal. of groundwater was purged at SCI-2 during development activities. Table B-1.1-1 (Appendix B) presents the volume of water removed during well development and the corresponding water-quality parameters.

A discussions of analytical results for samples collected during development is presented in Appendix B.

R-43

Well development was conducted between October 21 and October 30, 2008. Initially, both screened intervals were bailed and swabbed to remove formation fines in the filter pack. Bailing and swabbing methods were used until returned water was reasonably clear, and then a submersible pump was utilized to complete development. The swabbing tool was a 4.25-in.-O.D. 1-in.-thick nylon disc attached to a steel rod. The swabbing tool was lowered by wireline and drawn repeatedly across the screened interval. After bailing and swabbing, a 5-hp, 4-in. Grundfos submersible pump and shroud-packer assembly was installed in the well for the final stage of well development. The upper and lower screens were developed separately by isolating them with a packer during pumping development.

During the pumping stage of well development, turbidity, temperature, pH, DO, ORP, and specific conductance parameters were collected. In addition, water samples for TOC analysis were collected. The required values for TOC and turbidity by the end of well development are less than 2.0 ppm and less than 5 NTUs, respectively. The TOC measurement at the end of R-43 well development for the upper screened interval was less than 0.5 ppm and turbidity measurement was 2.2 NTUs, while the lower screen interval TOC measurement was less than 0.5 ppm and turbitdity was 3.4 NTUs.

Approximately 6677 gal. (total) of groundwater was purged at R-43 during development activities. A discussion of analytical results for samples collected during development is presented in Appendix B.

Field Parameters

SCI-2

The results for field parameters collected during well development, consisting of pH, temperature, DO, ORP, specific conductance, and turbidity, are provided in Table B-1.2-1 in Appendix B. Field parameters were measured at well SCI-2 by collecting aliquots of groundwater from the discharge pipe without the use of a flow-through cell, allowing the samples to be exposed to the atmosphere. This condition probably resulted in a slight variation of field parameters during well development and during the pumping test, most notably, temperature, pH, and DO. Measurements of pH and temperature varied from 7.23 to 7.67 and from 14.1°C to 21.52°C, respectively, at well SCI-2. Temperature variability may have resulted either from a malfunctioning instrument or the measurements were influenced by land surface-atmosphere conditions during sampling. Percent saturation of DO varied from 5.90 to 9.23. Perched intermediate depth groundwater at well SCI-2 is relatively oxidizing, based on DO and ORP measurements, with ORP varying from 185 to 216 millivolts (mV) (Table B-1.2-1). Most of the ORP readings measured at well SCI-2 were greater than +190 mV. Specific conductance ranged from 544 to 600 microsiemens per centimeter (μS/cm). Reliable (positive values) measurements of turbidity measured at well SCI-2 ranged from 0.6 to to 7.8 nephelometric turbidity units (NTUs) for the nonfiltered groundwater samples

R-43

Results for field parameters collected during well development, consisting of pH, temperature, DO, ORP, specific conductance, and turbidity, are provided by screen interval in Table B-1.2-1 of Appendix B. Measurements of pH and temperature varied from 8.37 to 9.22 and from 14.1°C to 22.3°C, respectively, at well R-43 during well development, with most of the temperature measurements warmer than 20°C. Percent saturation of DO varied from 41 to 73.8, suggesting that DO was measured between 2.99 and 5.38 mg/L at R-43 during well development. This assumes that 7.29 mg/L of DO represents complete (100%) saturation at 6000 ft and 20°C. Regional aquifer groundwater is relatively oxidizing at well R-43 based on DO and ORP measurements, with ORP varying from 76.2 to 185 mV (Table B-1.2-1). Most of the ORP readings taken during well development were greater than +110 mV. Specific conductance ranged from 175 to 212 μS/cm during well development at R-43. Values of turbidity measured at R-43 ranged from 0.7 to 85.4 NTUs for the nonfiltered groundwater samples.

Results for field parameters collected during aquifer testing, consisting of pH, temperature, DO, ORP, specific conductance, and turbidity, are provided by screen interval in Table B.1.2-1 of Appendix B. Measurements of pH and temperature varied from 8.21 to 9.18 and from 18.51°C to 21.6°C, respectively, at well R-43 during aquifer performance testing. Percent saturation of DO varied from 24.6 to 91.3, suggesting that DO was measured between 1.79 and 6.66 mg/L at R-43 during well development. This assumes that 7.29 mg/L of DO represents complete (100%) saturation at 6000 ft and 20°C. The ORP measurements substantially varied from –109 to 62.1 mV with negative, nonadjusted ORP values recorded for samples pumped from both screens (Table B-1.2-1). The ORP measurements taken during well development are considered to be more reliable than those taken during aquifer performance testing, based on percent saturation of DO and dissolved concentrations of nitrate(N) and sulfate. Specific conductance ranged from 174 to 202 μS/cm during aquifer performance testing at R-43.

8.2 Aquifer Testing

SCI-2

No aquifer testing was conducted on the SCI-2 well.

R-43

Aquifer pumping tests were conducted on both screens at R-43 between October 31 and November 17, 2008. Three short-duration tests with short-duration recovery periods were performed before carrying out a 24-h constant rate test. The 24-h constant rate test was then followed by a 24-h recovery period. The same 5-hp Grundfos pump used during well development was used to perform the aquifer tests. The results of the R-43 aquifer test are presented in Appendix C.

8.3 Dedicated Sampling System Installation

SCI-2

A dedicated sampling system composed of a pneumatic Bennett pump was installed in SCI-2 on February 3, 2009. The Bennett pump is a model 1400-6 and is hung in the well on a tube bundle that includes a Teflon water-discharge line. The pump intake is set just above the screen interval at a depth of 547.3 ft bgs. An In-Situ Level Troll 500 transducer was installed with and banded to the pump's tube bundle. Because of the small diameter of the SCI-2 well, the transducer was not set in a dedicated PVC tube and is not readily removable. A schematic of the pump and surface equipment is shown in Figure 8.3-1a; details of the technical notes are shown in Figure 8.3-1b.

R-43

The dedicated sampling system for R-43 has been designed but has not yet been delivered and installed. The system will be a Baski Inc., manufactured system that will utilize a single 3-hp, 4-in.-O.D. environmentally retrofitted Grundfos submersible pump capable of purging each screen interval discretely via pneumatically actuated access port valves. The system will include a Viton-wrapped isolation packer between the screen intervals. Pump riser pipe will consist of threaded and coupled nonannealed 1-in.-diameter stainless steel. Two 1-in.-diameter PVC tubes will be installed along with and banded to the pump riser for dedicated transducers. The tubes will be 1.0-in.-I.D. flush-threaded schedule 80 PVC pipe. Each PVC tube will have 6-in.-long 0.010-in. screen-slot intervals at the bottom of the tube with threaded bottom caps. Two In-Situ Level Troll 500 transducers will be installed in the PVC tubes to monitor water levels in each screen interval. Postinstallation construction and sampling system component installation details for R-43 are presented in Figure 8.3-2a. Figure 8.3-2b presents technical notes.

8.4 Wellhead Completion

A reinforced concrete surface pad, 10 ft × 10 ft × 6 in. thick, was installed at both the SCI-2 and R-43 well heads. The pads will provide long-term structural integrity for both wells. A brass survey pin was embedded in the northwest corner of each pad. Ten inch-I.D. steel protective casing with locking lids was installed around both well risers. Both concrete pads were slightly elevated above the ground surface and crowned to promote runoff. Base course was graded around the edges of each pad. Details of the wellhead completions are presented in Figures 8.3-1a and 8.3-2a.

8.5 Geodetic Survey

Geodetic survey data for the well casing top cap, 10-in. protective casing, brass pin, and ground surface at SCI-2 and R-43 were collected on February 10, 2009. The survey data are presented in Figures 8.3-1b and 8.3-2b and in Table 8.5-1. The survey data were collected by a licensed surveyor and 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 as New Mexico State Plane Coordinate System Central Zone (NAD 83); elevation is expressed in feet above mean sea level using the National Geodetic Vertical Datum of 1929.

8.6 Waste Management and Site Restoration

Waste generation and characterization for the SCI-2/R-43 project included a small quantity of contact waste, decontamination fluids, drill cuttings, discharged drilling water, cement slurry, and purged groundwater. Waste characterization samples of drill cuttings, purge water, and a small amount of oil contaminated soil were collected on August 13 and 28, 2008, for SCI-2 and on several occasions from August 26 to November 11, 2008, for R-43. Table 8.6-1 summarizes the waste samples collected for the SCI-2/R-43 well project.

Fluids, cuttings, cement slurry, and contact waste produced during drilling and development were containerized and sampled in accordance with “Waste Characterization Strategy Form for Chromium Wells (R-42, SCI-2/R-43) and Corehole Installation” (LANL 2008, 101914).

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 (WSCF) and the EP-Directorate Standard Operating Procedure (SOP) 010.0, Land Application of Groundwater. If it is determined that drilling fluids are nonhazardous but cannot meet the criterion for land application, the water will be evaluated for treatment and disposal at one of the Laboratory’s six wastewater treatment facilities. If analytical data indicate that the drilling fluids are hazardous/nonradioactive or mixed low-level waste, the waste 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-Resource Conservation Recovery Act SOP-011.0, Land Application of Drill Cuttings. If the drill cuttings do not meet the criterion for land application, they will be removed from the pit and disposed of at an authorized facility. The cement slurry waste stream will be managed as industrial nonhazardous waste, pending analytical review. Disposal of this concrete slurry will take place at an authorized disposal facility. Characterization of contact waste will be based upon acceptable knowledge, pending the results of the waste samples collected from the drill cuttings, purge water, and cement slurry.

Site restoration activities will include removing water from the cuttings containment pit and land-applying it on-site (if applicable), removing the polyethylene liner, removing the containment area berms, and backfilling and regrading the containment area. Cuttings will be managed in accordance with SOP-011.0 referenced above. The site will be reseeded with a native seed mix consisting of Indian rice grass, mountain broam, blue stem, sand drop, and slender wheat grass seed. The Laboratory-approved seed mix will be applied at the required rate of 20 lb/acre; Biosol fertilizer will be applied at a rate of 80 lb/acre.

9.0 DEVIATIONS FROM PLANNED ACTIVITIES

Drilling/coring and sampling at SCI-2 were performed as specified in "Drilling Plan for SCI-2/Regional Aquifer Well R-43," prepared for Los Alamos National Laboratory, Los Alamos, New Mexico (TerranearPMC 2008, 103942). The major deviation from planned activities was the decision to complete the core hole as an intermediate depth aquifer monitoring well instead of abandoning the borehole.

Drilling, sampling, and well construction at R-43 were performed as specified in "Drilling Plan for SCI-2/Regional Aquifer Well R-43," prepared for Los Alamos National Laboratory, Los Alamos, New Mexico (TerranearPMC 2008, 103942).

Well construction activities at R-43 did not plan to leave the 16-in. casing in the upper portion of the borehole.

10.0 ACKNOWLEDGMENTS

P. Longmire of Los Alamos National Laboratory contributed the geochemistry section of this report (Appendix B).

Boart Longyear drilled the SCI-2 core hole and installed the well.

S.G. Western prepared the site for drilling activities.

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

11.0 REFERENCES

The following list includes all documents cited in the main text of this report. Parenthetical information following each reference provides the author(s), publication date, and ER ID number. This information is also included in text citations. ER ID numbers 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), 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), November 2007. "Work Plan for Geochemical Characterization and Drilling for Fate and Transport of Contaminants Originating in Sandia Canyon," Los Alamos National Laboratory document LA-UR-07-7579, Los Alamos, New Mexico. (LANL 2007, 099607)

LANL (Los Alamos National Laboratory), May 2008. "Waste Characterization Strategy Form for the Chromium Wells (R-42 and SCI-2/R-43) Regional Groundwater Well Installation and Corehole Drilling," Los Alamos, New Mexico. (LANL 2008, 101914)

TerranearPMC, May 2008. "Drilling Plan for SCI-2/Regional Aquifer Well R-43," plan prepared for Los Alamos National Laboratory, Los Alamos, New Mexico. (TerranearPMC 2008, 103942)

11.1 Map Data Sources

Los Alamos National Laboratory, Waste and Environmental Services Division, EP2008-0109, 28 February 2008

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

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

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

Technical Area Boundaries, Los Alamos National Laboratory, Site Planning and Project Initiation

Group, Infrastructure Planning Division, 19 September 2007.

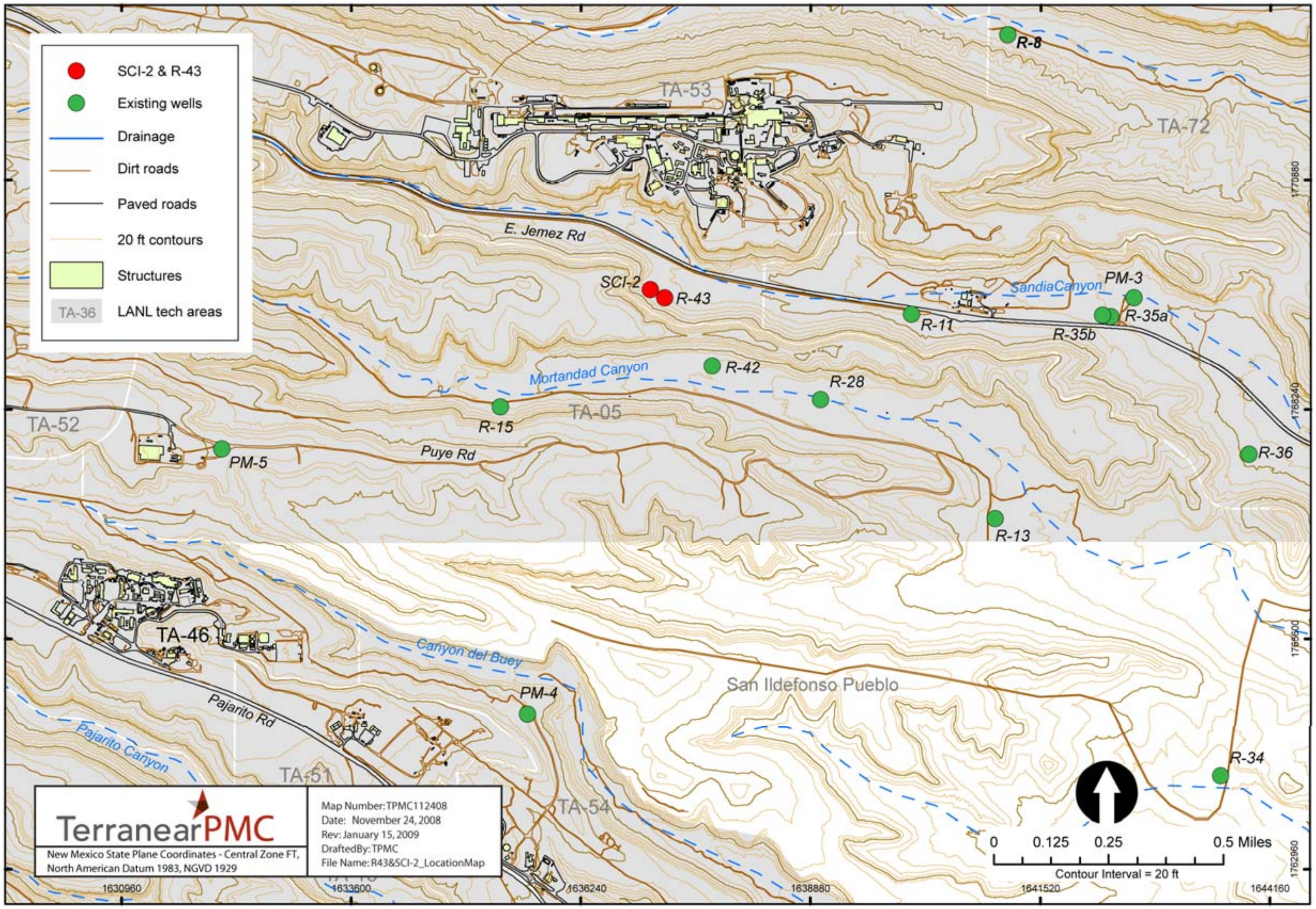
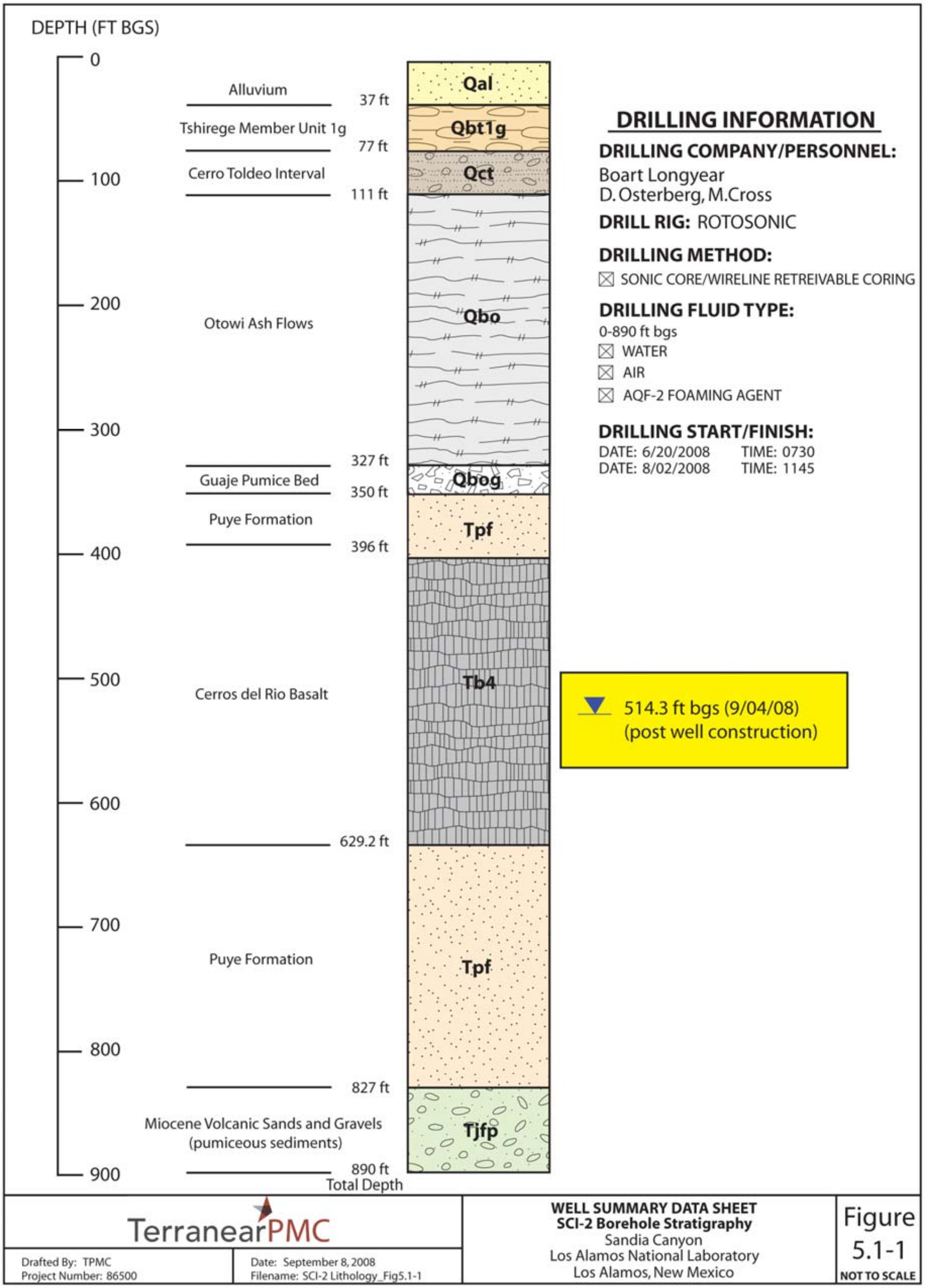


Figure 1.0-1 Location of regional aquifer well R-43 and SCI-2 with respect to municipal supply wells PM-3, PM-4, and PM-5 and additional surrounding regional groundwater monitoring wells



DRILLING INFORMATION

DRILLING COMPANY/PERSONNEL:
Boart Longyear
D. Osterberg, M.Cross

DRILL RIG: ROTOSONIC

DRILLING METHOD:
☒ SONIC CORE/WIRELINE RETREIVABLE CORING

DRILLING FLUID TYPE:
0-890 ft bgs
☒ WATER
☒ AIR
☒ AQF-2 FOAMING AGENT

DRILLING START/FINISH:
DATE: 6/20/2008 TIME: 0730
DATE: 8/02/2008 TIME: 1145

Drafted By: TPMC
Project Number: 86500

Date: September 8, 2008
Filename: SCI-2 Lithology_Fig5.1-1

WELL SUMMARY DATA SHEET
SCI-2 Borehole Stratigraphy
Sandia Canyon
Los Alamos National Laboratory
Los Alamos, New Mexico

Figure 5.1-1 SCI-2 corehole stratigraphy

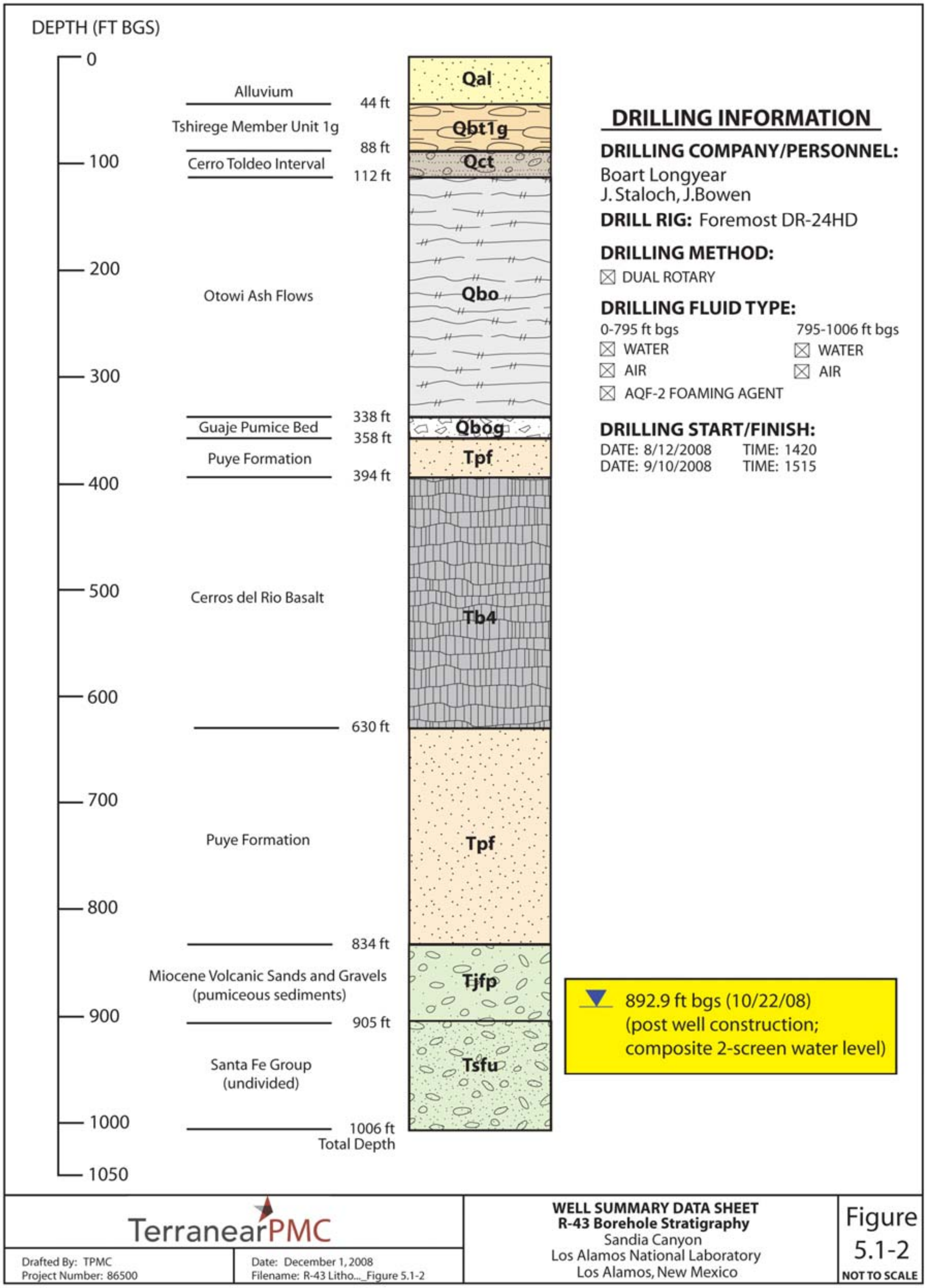
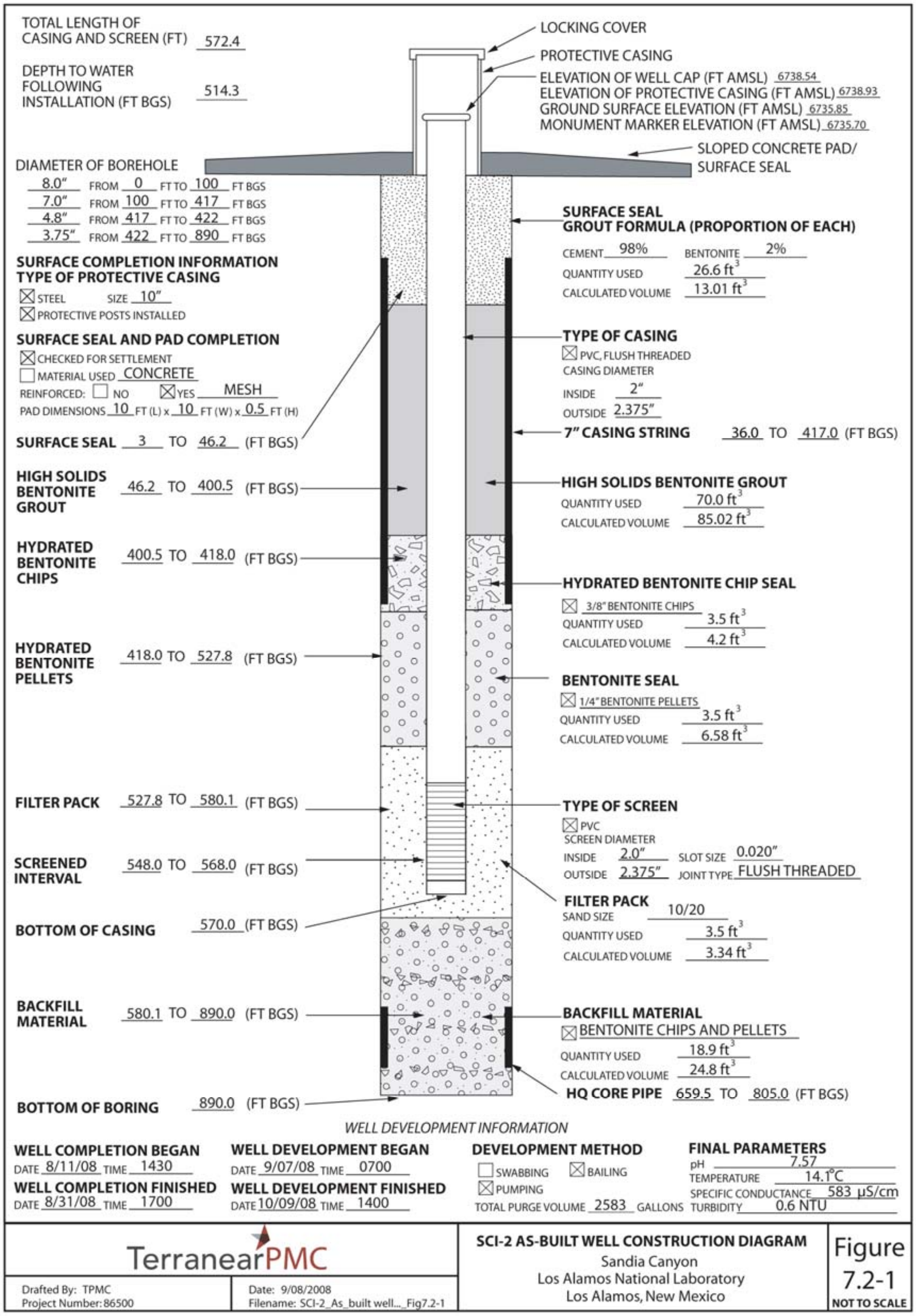


Figure 5.1-2 R-43 borehole stratigraphy



TOTAL LENGTH OF CASING AND SCREEN (FT) 572.4

DEPTH TO WATER FOLLOWING INSTALLATION (FT BGS) 514.3

ELEVATION OF WELL CAP (FT AMSL) 6738.54
ELEVATION OF PROTECTIVE CASING (FT AMSL) 6738.93
GROUND SURFACE ELEVATION (FT AMSL) 6735.85
MONUMENT MARKER ELEVATION (FT AMSL) 6735.70

DIAMETER OF BOREHOLE
8.0" FROM 0 FT TO 100 FT BGS
7.0" FROM 100 FT TO 417 FT BGS
4.8" FROM 417 FT TO 422 FT BGS
3.75" FROM 422 FT TO 890 FT BGS

SURFACE COMPLETION INFORMATION
TYPE OF PROTECTIVE CASING
☒ STEEL SIZE 10"
☒ PROTECTIVE POSTS INSTALLED

SURFACE SEAL AND PAD COMPLETION
☒ CHECKED FOR SETTLEMENT
☐ MATERIAL USED CONCRETE
REINFORCED: ☐ NO ☒ YES MESH
PAD DIMENSIONS 10 FT (L) x 10 FT (W) x 0.5 FT (H)

SURFACE SEAL 3 TO 46.2 (FT BGS)

HIGH SOLIDS BENTONITE GROUT 46.2 TO 400.5 (FT BGS)

HYDRATED BENTONITE CHIPS 400.5 TO 418.0 (FT BGS)

HYDRATED BENTONITE PELLETS 418.0 TO 527.8 (FT BGS)

FILTER PACK 527.8 TO 580.1 (FT BGS)

SCREENED INTERVAL 548.0 TO 568.0 (FT BGS)

BOTTOM OF CASING 570.0 (FT BGS)

BACKFILL MATERIAL 580.1 TO 890.0 (FT BGS)

BOTTOM OF BORING 890.0 (FT BGS)

SURFACE SEAL
GROUT FORMULA (PROPORTION OF EACH)
CEMENT 98% BENTONITE 2%
QUANTITY USED 26.6 ft^3
CALCULATED VOLUME 13.01 ft^3

TYPE OF CASING
☒ PVC, FLUSH THREADED
CASING DIAMETER
INSIDE 2"
OUTSIDE 2.375"

7" CASING STRING 36.0 TO 417.0 (FT BGS)

HIGH SOLIDS BENTONITE GROUT
QUANTITY USED 70.0 ft^3
CALCULATED VOLUME 85.02 ft^3

HYDRATED BENTONITE CHIP SEAL
☒ 3/8" BENTONITE CHIPS
QUANTITY USED 3.5 ft^3
CALCULATED VOLUME 4.2 ft^3

BENTONITE SEAL
☒ 1/4" BENTONITE PELLETS
QUANTITY USED 3.5 ft^3
CALCULATED VOLUME 6.58 ft^3

TYPE OF SCREEN
☒ PVC
SCREEN DIAMETER
INSIDE 2.0" SLOT SIZE 0.020"
OUTSIDE 2.375" JOINT TYPE FLUSH THREADED

FILTER PACK
SAND SIZE 10/20
QUANTITY USED 3.5 ft^3
CALCULATED VOLUME 3.34 ft^3

BACKFILL MATERIAL
☒ BENTONITE CHIPS AND PELLETS
QUANTITY USED 18.9 ft^3
CALCULATED VOLUME 24.8 ft^3

HQ CORE PIPE 659.5 TO 805.0 (FT BGS)

WELL DEVELOPMENT INFORMATION

WELL COMPLETION BEGAN
DATE 8/11/08 TIME 1430
WELL COMPLETION FINISHED
DATE 8/31/08 TIME 1700

WELL DEVELOPMENT BEGAN
DATE 9/07/08 TIME 0700
WELL DEVELOPMENT FINISHED
DATE 10/09/08 TIME 1400

DEVELOPMENT METHOD
☐ SWABBING ☒ BAILING
☒ PUMPING
TOTAL PURGE VOLUME 2583 GALLONS

FINAL PARAMETERS
pH 7.57
TEMPERATURE 14.1°C
SPECIFIC CONDUCTANCE 583 µS/cm
TURBIDITY 0.6 NTU

TerranearPMC

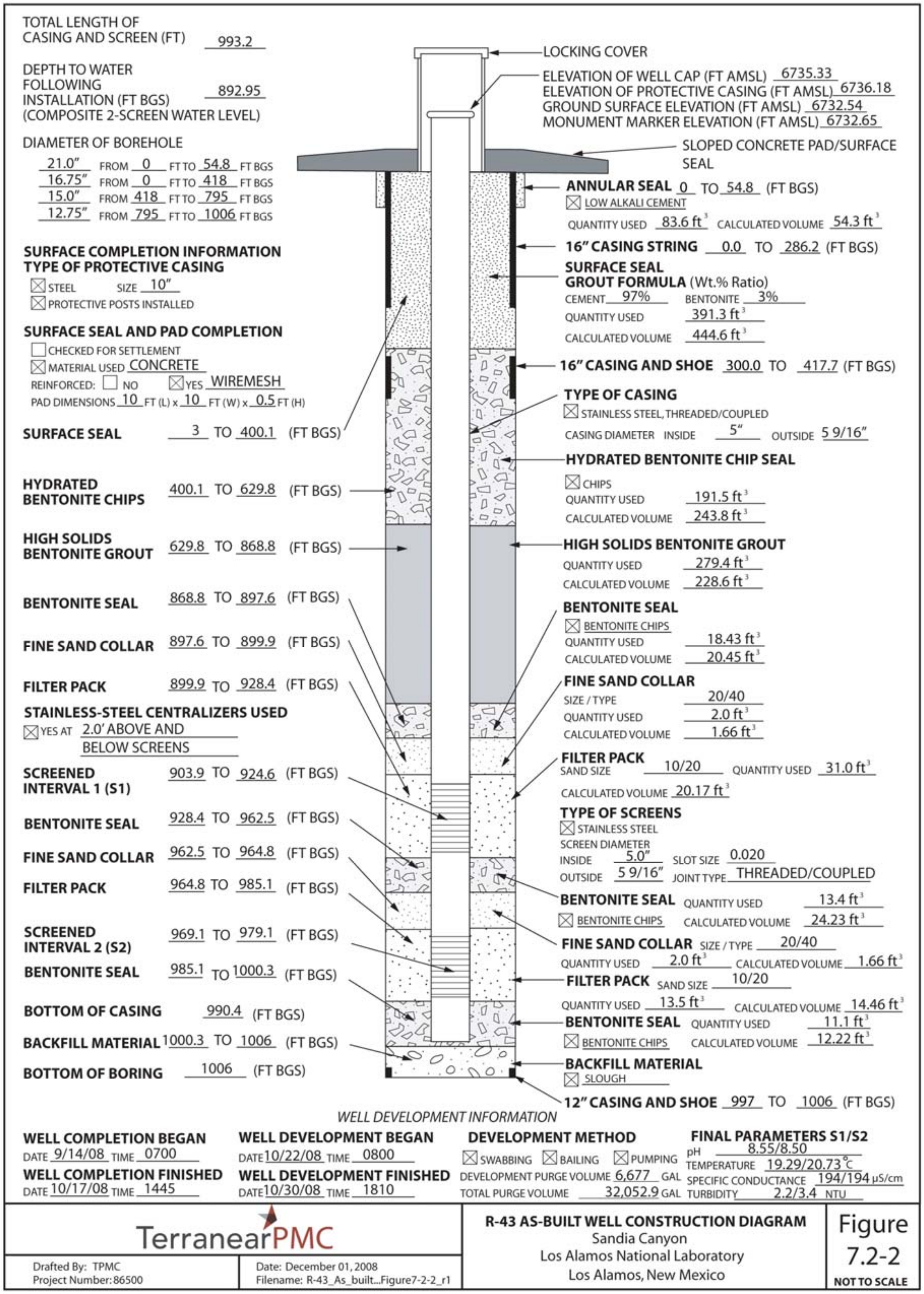
Drafted By: TPMC
Project Number: 86500

Date: 9/08/2008
Filename: SCI-2_As_built well..._Fig7.2-1

SCI-2 AS-BUILT WELL CONSTRUCTION DIAGRAM
Sandia Canyon
Los Alamos National Laboratory
Los Alamos, New Mexico

Figure
7.2-1
NOT TO SCALE

Figure 7.2-1 SCI-2 As-built construction diagram



TOTAL LENGTH OF CASING AND SCREEN (FT) 993.2

DEPTH TO WATER FOLLOWING INSTALLATION (FT BGS) 892.95
(COMPOSITE 2-SCREEN WATER LEVEL)

DIAMETER OF BOREHOLE
21.0" FROM 0 FT TO 54.8 FT BGS
16.75" FROM 0 FT TO 418 FT BGS
15.0" FROM 418 FT TO 795 FT BGS
12.75" FROM 795 FT TO 1006 FT BGS

SURFACE COMPLETION INFORMATION
TYPE OF PROTECTIVE CASING
☒ STEEL SIZE 10"
☒ PROTECTIVE POSTS INSTALLED

SURFACE SEAL AND PAD COMPLETION
☐ CHECKED FOR SETTLEMENT
☒ MATERIAL USED CONCRETE
REINFORCED: ☐ NO ☒ YES WIREMESH
PAD DIMENSIONS 10 FT (L) x 10 FT (W) x 0.5 FT (H)

SURFACE SEAL 3 TO 400.1 (FT BGS)

HYDRATED BENTONITE CHIPS 400.1 TO 629.8 (FT BGS)

HIGH SOLIDS BENTONITE GROUT 629.8 TO 868.8 (FT BGS)

BENTONITE SEAL 868.8 TO 897.6 (FT BGS)

FINE SAND COLLAR 897.6 TO 899.9 (FT BGS)

FILTER PACK 899.9 TO 928.4 (FT BGS)

STAINLESS-STEEL CENTRALIZERS USED
☒ YES AT 2.0' ABOVE AND BELOW SCREENS

SCREENED INTERVAL 1 (S1) 903.9 TO 924.6 (FT BGS)

BENTONITE SEAL 928.4 TO 962.5 (FT BGS)

FINE SAND COLLAR 962.5 TO 964.8 (FT BGS)

FILTER PACK 964.8 TO 985.1 (FT BGS)

SCREENED INTERVAL 2 (S2) 969.1 TO 979.1 (FT BGS)

BENTONITE SEAL 985.1 TO 1000.3 (FT BGS)

BOTTOM OF CASING 990.4 (FT BGS)

BACKFILL MATERIAL 1000.3 TO 1006 (FT BGS)

BOTTOM OF BORING 1006 (FT BGS)

LOCKING COVER

ELEVATION OF WELL CAP (FT AMSL) 6735.33
ELEVATION OF PROTECTIVE CASING (FT AMSL) 6736.18
GROUND SURFACE ELEVATION (FT AMSL) 6732.54
MONUMENT MARKER ELEVATION (FT AMSL) 6732.65

SLOPED CONCRETE PAD/SURFACE SEAL

ANNULAR SEAL 0 TO 54.8 (FT BGS)
☒ LOW ALKALI CEMENT
QUANTITY USED 83.6 ft³ CALCULATED VOLUME 54.3 ft³

16" CASING STRING 0.0 TO 286.2 (FT BGS)

SURFACE SEAL
GROUT FORMULA (Wt.% Ratio)
CEMENT 97% BENTONITE 3%
QUANTITY USED 391.3 ft³
CALCULATED VOLUME 444.6 ft³

16" CASING AND SHOE 300.0 TO 417.7 (FT BGS)

TYPE OF CASING
☒ STAINLESS STEEL, THREADED/COUPLED
CASING DIAMETER INSIDE 5" OUTSIDE 5 9/16"

HYDRATED BENTONITE CHIP SEAL
☒ CHIPS
QUANTITY USED 191.5 ft³
CALCULATED VOLUME 243.8 ft³

HIGH SOLIDS BENTONITE GROUT
QUANTITY USED 279.4 ft³
CALCULATED VOLUME 228.6 ft³

BENTONITE SEAL
☒ BENTONITE CHIPS
QUANTITY USED 18.43 ft³
CALCULATED VOLUME 20.45 ft³

FINE SAND COLLAR
SIZE / TYPE 20/40
QUANTITY USED 2.0 ft³
CALCULATED VOLUME 1.66 ft³

FILTER PACK
SAND SIZE 10/20 QUANTITY USED 31.0 ft³
CALCULATED VOLUME 20.17 ft³

TYPE OF SCREENS
☒ STAINLESS STEEL
SCREEN DIAMETER
INSIDE 5.0" SLOT SIZE 0.020
OUTSIDE 5 9/16" JOINT TYPE THREADED/COUPLED

BENTONITE SEAL QUANTITY USED 13.4 ft³
☒ BENTONITE CHIPS CALCULATED VOLUME 24.23 ft³

FINE SAND COLLAR SIZE / TYPE 20/40
QUANTITY USED 2.0 ft³ CALCULATED VOLUME 1.66 ft³

FILTER PACK SAND SIZE 10/20
QUANTITY USED 13.5 ft³ CALCULATED VOLUME 14.46 ft³

BENTONITE SEAL QUANTITY USED 11.1 ft³
☒ BENTONITE CHIPS CALCULATED VOLUME 12.22 ft³

BACKFILL MATERIAL
☒ SLOUGH

12" CASING AND SHOE 997 TO 1006 (FT BGS)

WELL DEVELOPMENT INFORMATION

WELL COMPLETION BEGAN
DATE 9/14/08 TIME 0700
WELL COMPLETION FINISHED
DATE 10/17/08 TIME 1445

WELL DEVELOPMENT BEGAN
DATE 10/22/08 TIME 0800
WELL DEVELOPMENT FINISHED
DATE 10/30/08 TIME 1810

DEVELOPMENT METHOD
☒ SWABBING ☒ BAILING ☒ PUMPING
DEVELOPMENT PURGE VOLUME 6,677 GAL
TOTAL PURGE VOLUME 32,052.9 GAL

FINAL PARAMETERS S1/S2
pH 8.55/8.50
TEMPERATURE 19.29/20.73 °C
SPECIFIC CONDUCTANCE 194/194 μS/cm
TURBIDITY 2.2/3.4 NTU

TerranearPMC

Drafted By: TPMC
Project Number: 86500

Date: December 01, 2008
Filename: R-43_As_built...Figure7-2-2_r1

R-43 AS-BUILT WELL CONSTRUCTION DIAGRAM
Sandia Canyon
Los Alamos National Laboratory
Los Alamos, New Mexico

Figure 7.2-2
NOT TO SCALE

Figure 7.2-2 R-43 As-built construction diagram

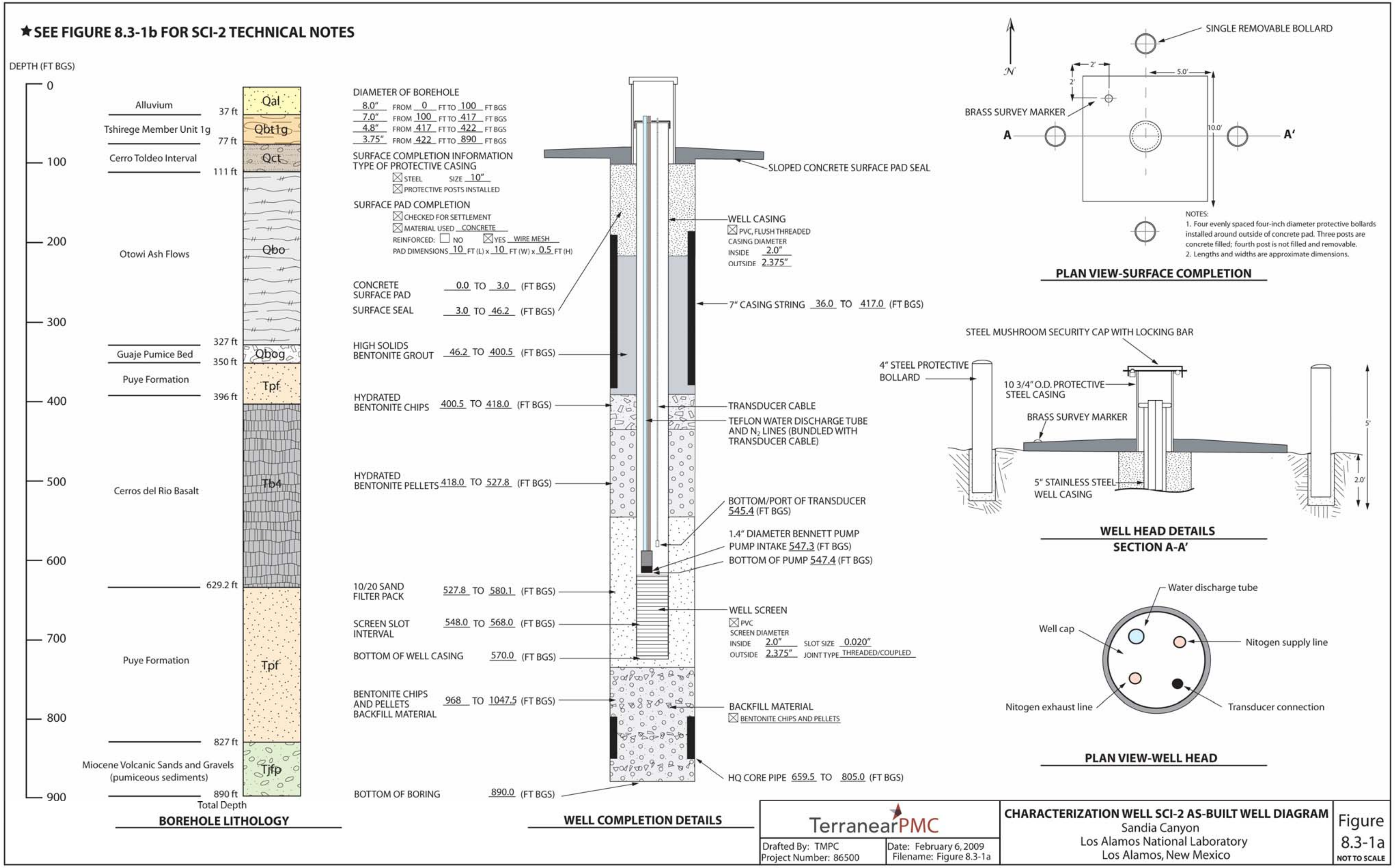
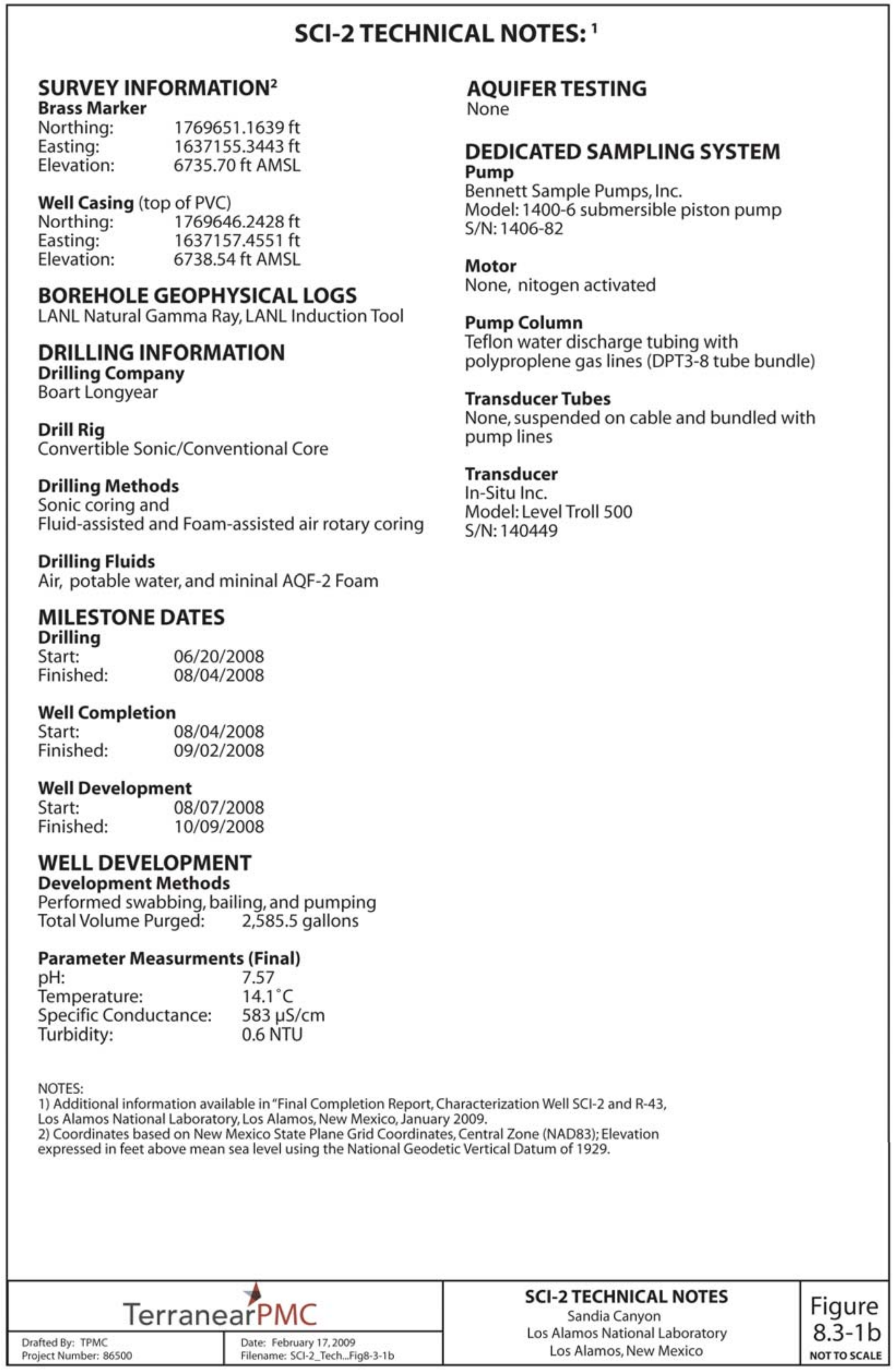


Figure 8.3-1a **As-built schematic for intermediate well SCI-2**



SCI-2 TECHNICAL NOTES: [1]

SURVEY INFORMATION[2]

Brass Marker

Northing:	1769651.1639 ft
Easting:	1637155.3443 ft
Elevation:	6735.70 ft AMSL

Well Casing (top of PVC)

Northing:	1769646.2428 ft
Easting:	1637157.4551 ft
Elevation:	6738.54 ft AMSL

BOREHOLE GEOPHYSICAL LOGS

LANL Natural Gamma Ray, LANL Induction Tool

DRILLING INFORMATION

Drilling Company

Boart Longyear

Drill Rig

Convertible Sonic/Conventional Core

Drilling Methods

Sonic coring and
Fluid-assisted and Foam-assisted air rotary coring

Drilling Fluids

Air, potable water, and mininal AQF-2 Foam

MILESTONE DATES

Drilling

Start:	06/20/2008
Finished:	08/04/2008

Well Completion

Start:	08/04/2008
Finished:	09/02/2008

Well Development

Start:	08/07/2008
Finished:	10/09/2008

WELL DEVELOPMENT

Development Methods

Performed swabbing, bailing, and pumping

Total Volume Purged:	2,585.5 gallons

Parameter Measurments (Final)

pH:	7.57
Temperature:	14.1°C
Specific Conductance:	583 µS/cm
Turbidity:	0.6 NTU

AQUIFER TESTING

None

DEDICATED SAMPLING SYSTEM

Pump

Bennett Sample Pumps, Inc.
Model: 1400-6 submersible piston pump
S/N: 1406-82

Motor

None, nitogen activated

Pump Column

Teflon water discharge tubing with polyproplene gas lines (DPT3-8 tube bundle)

Transducer Tubes

None, suspended on cable and bundled with pump lines

Transducer

In-Situ Inc.
Model: Level Troll 500
S/N: 140449

NOTES:
1) Additional information available in "Final Completion Report, Characterization Well SCI-2 and R-43, Los Alamos National Laboratory, Los Alamos, New Mexico, January 2009.
2) Coordinates based on New Mexico State Plane Grid Coordinates, Central Zone (NAD83); Elevation expressed in feet above mean sea level using the National Geodetic Vertical Datum of 1929.

TerranearPMC

Drafted By: TPMC
Project Number: 86500

Date: February 17, 2009
Filename: SCI-2_Tech...Fig8-3-1b

SCI-2 TECHNICAL NOTES
Sandia Canyon
Los Alamos National Laboratory
Los Alamos, New Mexico

Figure
8.3-1b
NOT TO SCALE

Figure 8.3-1b As-built technical notes for SCI-2

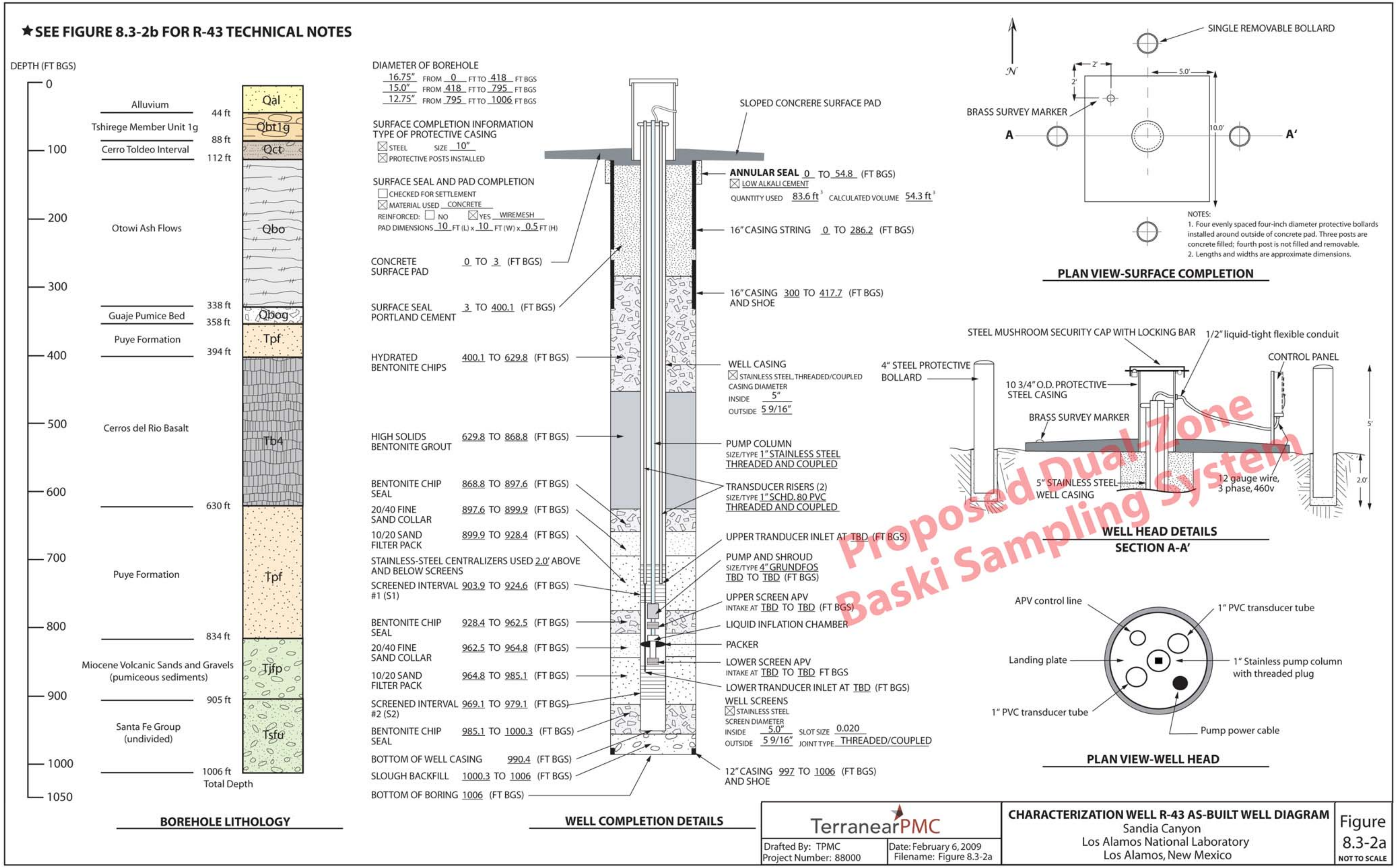
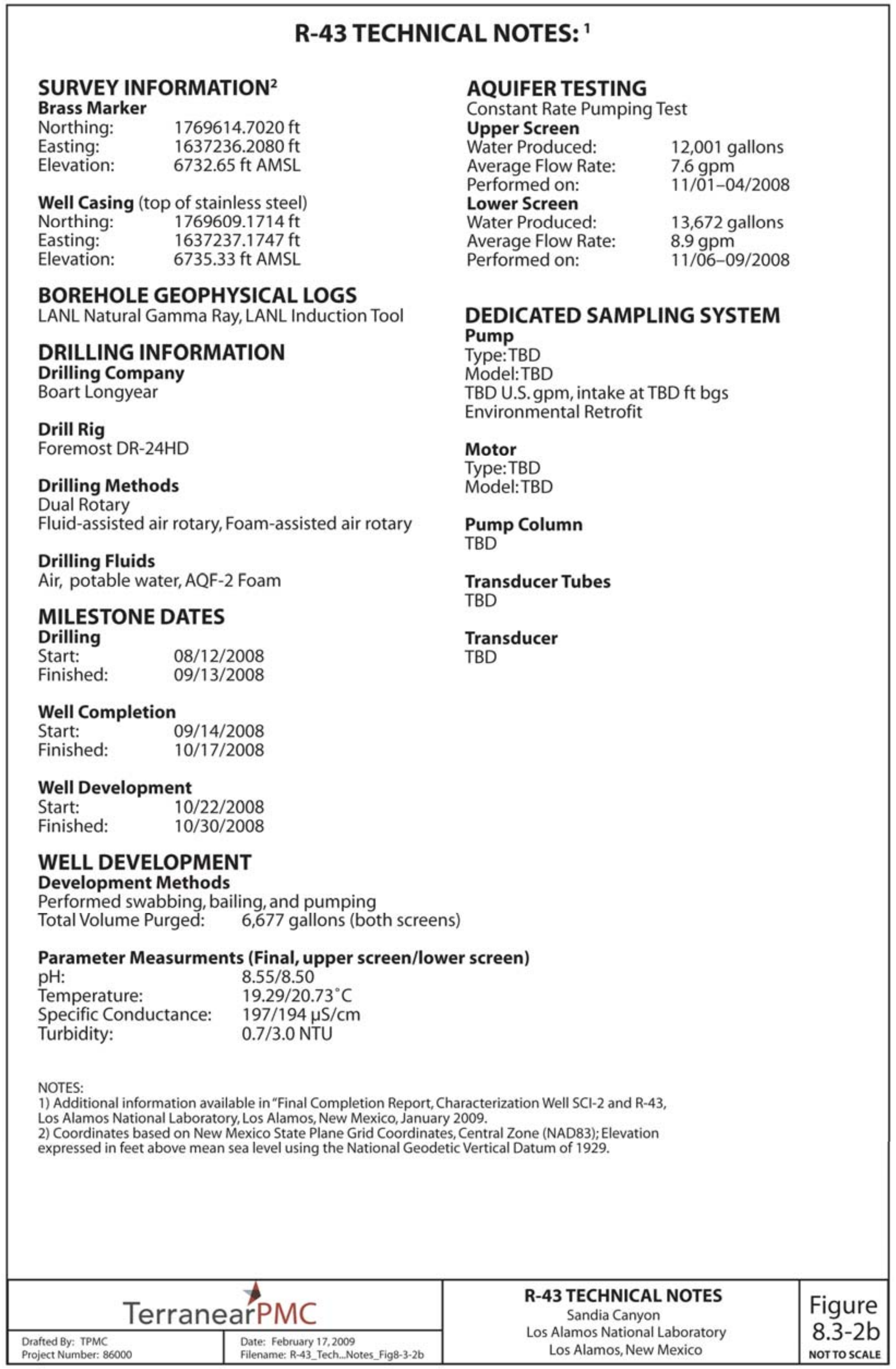


Figure 8.3-2a As-built schematic for regional well R-43



R-43 TECHNICAL NOTES: [1]

SURVEY INFORMATION[2]

Brass Marker
Northing: 1769614.7020 ft
Easting: 1637236.2080 ft
Elevation: 6732.65 ft AMSL

Well Casing (top of stainless steel)
Northing: 1769609.1714 ft
Easting: 1637237.1747 ft
Elevation: 6735.33 ft AMSL

BOREHOLE GEOPHYSICAL LOGS

LANL Natural Gamma Ray, LANL Induction Tool

DRILLING INFORMATION

Drilling Company
Boart Longyear

Drill Rig
Foremost DR-24HD

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

Drilling Fluids
Air, potable water, AQF-2 Foam

MILESTONE DATES

Drilling
Start: 08/12/2008
Finished: 09/13/2008

Well Completion
Start: 09/14/2008
Finished: 10/17/2008

Well Development
Start: 10/22/2008
Finished: 10/30/2008

WELL DEVELOPMENT

Development Methods
Performed swabbing, bailing, and pumping
Total Volume Purged: 6,677 gallons (both screens)

Parameter Measurments (Final, upper screen/lower screen)
pH: 8.55/8.50
Temperature: 19.29/20.73°C
Specific Conductance: 197/194 µS/cm
Turbidity: 0.7/3.0 NTU

AQUIFER TESTING

Constant Rate Pumping Test
Upper Screen
Water Produced: 12,001 gallons
Average Flow Rate: 7.6 gpm
Performed on: 11/01–04/2008
Lower Screen
Water Produced: 13,672 gallons
Average Flow Rate: 8.9 gpm
Performed on: 11/06–09/2008

DEDICATED SAMPLING SYSTEM

Pump
Type: TBD
Model: TBD
TBD U.S. gpm, intake at TBD ft bgs
Environmental Retrofit

Motor
Type: TBD
Model: TBD

Pump Column
TBD

Transducer Tubes
TBD

Transducer
TBD

NOTES:
1) Additional information available in "Final Completion Report, Characterization Well SCI-2 and R-43, Los Alamos National Laboratory, Los Alamos, New Mexico, January 2009.
2) Coordinates based on New Mexico State Plane Grid Coordinates, Central Zone (NAD83); Elevation expressed in feet above mean sea level using the National Geodetic Vertical Datum of 1929.

TerranearPMC
Drafted By: TPMC
Project Number: 86000
Date: February 17, 2009
Filename: R-43_Tech...Notes_Fig8-3-2b

R-43 TECHNICAL NOTES
Sandia Canyon
Los Alamos National Laboratory
Los Alamos, New Mexico

Figure
8.3-2b
NOT TO SCALE

Figure 8.3-2b As-built technical notes for R-43

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

	Date	Water (gal.)	Cumulative Water (gal.)	AQF-2 Foam (gal.)	Cumulative AQF-2 Foam (gal.)	Cumulative Returns in Pit: Fluids (gal.)
Drilling						
SCI-2	6/22/08	80	80	n/a[a]	n/a	n/r[b]
	6/23/08	40	120	n/a	n/a	n/r
	6/28/08	60	180	n/a	n/a	n/r
	7/1/08	30	210	n/a	n/a	n/r
	7/10/08	60	270	n/a	n/a	n/r
	7/11/08	111	381	n/a	n/a	n/r
	7/15/08	581	962	0.5	0.5	n/r
	7/16/08	2167	3129	2	2.5	n/r
	7/17/08	2365	5494	2.5	5	n/r
	7/18/08	1935	7429	2	7	n/r
	7/19/08	1830[c]	9259	1	8	n/r
	7/26/08	1227	10,486	1	9	n/r
	7/27/08	460	10,946	.25	9.25	n/r
	7/28/08	100	11,046	n/a	9.25	n/r
R-43	8/13/08	1500	1500	15	15	n/r
	8/14/08	2000	3500	15	30	n/r
	8/15/08	1500	5000	15	45	n/r
	8/16/08	1500	6500	15	60	n/r
	8/17/08	2000	8500	15	75	n/r
	8/18/08	1500	10,000	15	90	n/r
	8/20/08	2000	12,000	15	105	n/r
	8/21/08	2500	14,500	15	120	n/r
	8/22/08	50	14,550	1	121	n/r
	8/24/08	1700	16,200	10	131	n/r
	8/25/08	1800	18,000	10	141	n/r
	9/8/08	1000	19,000	n/a	141	n/r
	9/9/08	300	19,300	n/a	141	n/r
	9/10/08	200	19,500	n/a	141	n/r

Table 3.1-1 (Continued)

	Date	Water (gal.)	Cumulative Water (gal.)	AQF-2 Foam (gal.)	Cumulative AQF-2 Foam (gal.)	Cumulative Returns in Pit: Fluids (gal.)
Well Construction						
SCI-2	8/6/08	1000	12,046	no foam was used	9.25	n/r
	8/7/08	1845	13,891	no foam was used	9.25	n/r
	8/8/08	1100	14,991	no foam was used	9.25	n/r
	8/16/08	1000	15,991	no foam was used	9.25	n/r
	8/27/08	15	16,006	no foam was used	9.25	n/r
	8/28/08	75	16,081	no foam was used	9.25	n/r
	8/29/08	15	16,096	no foam was used	9.25	n/r
R-43	9/18/08	3000	22,500	no foam was used	141	n/r
	9/19/08	600	23,100	no foam was used	141	n/r
	9/20/08	400	23,500	no foam was used	141	n/r
	9/21/08	100	23,600	no foam was used	141	n/r
	9/22/08	100	23,700	no foam was used	141	n/r
	9/23/08	1800	25,500	no foam was used	141	n/r
	9/24/08	600	26,100	no foam was used	141	n/r
	9/25/08	1000	27,100	no foam was used	141	n/r
	9/26/08	800	27,900	no foam was used	141	n/r
	9/27/08	500	28,400	no foam was used	141	n/r
	9/28/08	700	29,100	no foam was used	141	n/r
	9/29/08	1100	30,200	no foam was used	141	n/r
	9/30/08	175	30,375	no foam was used	141	n/r
	10/1/08	700	31,075	no foam was used	141	n/r
	10/2/08	600	31,675	no foam was used	141	n/r
	10/9/08	1200	32,875	no foam was used	141	n/r
	10/10/08	1340	34,215	no foam was used	141	n/r
	10/13/08	2600	36,815	no foam was used	141	n/r
	10/14/08	1450	38,265	no foam was used	141	n/r
	10/15/08	450	38,715	no foam was used	141	n/r
	10/17/08	2200	40,915	no foam was used	141	n/r
Total Volume (gal.)						
SCI-2	16096					
R-43	40915					

[a] n/a = Not applicable.

[b] n/r = Not recorded.

[c] Four sacks of Baroid QUIK-GEL were added with 450 gal. of water (included as part of daily use of 1830 gal.).

Table 4.1-1
Summary of Core Samples Collected for Analysis during Drilling of Well SCI-2

Sample ID	Date Collection	Collection Depth (ft bgs)	Geologic Zone	Analyses
CASA-08-13554	6/20/08	120.0–120.2	Qbo	Moisture
CASA-08-13555	6/21/08	155.0–155.2	Qbo	Moisture
CASA-08-13556	6/21/08	190.0–190.2	Qbo	Moisture
CASA-08-13557	6/21/08	225.0–225.2	Qbo	Moisture
CASA-08-13558	6/22/08	260.0–260.2	Qbo	Moisture
CASA-08-13559	6/22/08	295.0–295.2	Qbo	Moisture
CASA-08-13560	6/22/08	335.0–335.2	Qbog	Moisture
CASA-08-13566	6/28/08	346.5–347.0	Qbog	Tritium, Moisture/Anions, 14N/15N
CASA-08-13567	6/28/08	354.0–354.5	upper Tpf	Tritium, Moisture/Anions, 14N/15N
CASA-08-13565	6/28/08	369.0–369.5	upper Tpf	Tritium, Moisture/Anions, 14N/15N
CASA-08-13569	6/28/08	378.0–379.0	upper Tpf	Tritium, Moisture/Anions, 14N/15N
CASA-08-13568	6/29/08	419.5–420.0	Tb4	Tritium, Moisture/Anions, 14N/15N
CASA-08-13570	7/16/08	450.5–451.5	Tb4	Moisture/Anions, N14/N15, Metals, Cr+6
CASA-08-13570	7/16/08	452.5–453.5	Tb4	Tritium
CASA-08-13571	7/17/08	482.5–483.5	Tb4	Tritium
CASA-08-13571	7/17/08	483.5–484.5	Tb4	Moisture/Anions, 14N/15N, Metals, Cr+6
CASA-08-13572	7/17/08	511.5–512.5	Tb4	Moisture/Anions, 14N /15N
CASA-08-13572	7/17/08	512.5–513.6	Tb4	Tritium
CASA-08-13573	7/17/08	540.3–541.4	Tb4	N14/N15
CASA-08-13573	7/17/08	541.4–542.4	Tb4	Moisture/Anions
CASA-08-13573	7/17/08	542.3–543.3	Tb4	Tritium
CASA-08-13574	7/17/08	571.5–572.0	Tb4	Tritium
CASA-08-13574	7/17/08	572.0–573.0	Tb4	Moisture/Anions, 14N /15N, Metals, Cr+6
CASA-08-13575	7/18/08	601.5–602.0	Tb4	Tritium
CASA-08-13575	7/18/08	602.0–603.0	Tb4	Moisture/Anions, 14N/15N, Metals, Cr+6
CASA-08-13576	7/18/08	627.0–627.5	Tb4	Tritium
CASA-08-13576	7/18/08	628.5–629.5	Tb4/ lower Tpf	Moisture/Anions, 14N/15N, Metals, Cr+6
CASA-08-13577	7/18/08	685.8–686.3	lower Tpf	Tritium
CASA-08-13577	7/18/08	686.3–687.3	lower Tpf	Moisture/Anions
CASA-08-13578	7/18/08	725.5–726.5	lower Tpf	Moisture/Anions
CASA-08-13578	7/18/08	726.5–727.5	lower Tpf	14N/15N
CASA-08-13578	7/18/08	727.5–728.0	lower Tpf	Tritium
CASA-08-13579	7/19/08	815.5–816.4	lower Tpf	Tritium
CASA-08-13579	7/19/08	817.4–818.4	lower Tpf	Moisture/Anions, 14N/15N, Metals, Cr+6
CASA-08-13582	7/19/08	827.0–827.5	lower Tpf/Tsfu	Tritium
CASA-08-13582	7/19/08	827.0–827.5	lower Tpf/Tsfu	Moisture/Anions
CASA-08-13580	7/19/08	845.5–846.0	Tsfu	Tritium

Table 4.1-1 (continued)

Sample ID	Date Collection	Collection Depth (ft bgs)	Geologic Zone	Analyses
CASA-08-13580	7/19/08	846.0–847.0	Tsfu	Moisture/Anions, 14N/15N, Metals, Cr+6
CASA-08-13583	7/19/08	855.5–856.5	Tsfu	Tritium
CASA-08-13583	7/19/08	855.5–856.5	Tsfu	Moisture/Anions
CASA-08-13581	7/19/08	870.5–871.0	Tsfu	Tritium
CASA-08-13581	7/19/08	871.0–872.0	Tsfu	Moisture/Anions, 14N/15N, Metals, Cr+6
CASA-08-13584	7/19/08	885.0–885.5	Tsfu	Tritium
CASA-08-13584	7/19/08	885.0–885.5	Tsfu	Moisture/Anions
CASA-08-13585	7/19/08	888.1–888.6	Tsfu	Tritium
CASA-08-13585	7/19/08	888.1–888.6	Tsfu	Moisture/Anions

Table 4.2-1
Summary of Groundwater Screening Samples Collected during Drilling, Well Development, and Aquifer Testing of Wells SCI-2 and R-43

Location ID	Sample ID	Date Collected	Collection Depth (ft bgs)	Sample Type
Drilling				
SCI-2	CASA-08-13655	8/1/08	590	Bailer, perched groundwater
R-43	CASA-08-14140	8/22/08	630–635	Intermediate groundwater
R-43	CASA-08-14141	9/9/08	894.5–895.0	Regional groundwater
R-43	CASA-08-14142	9/9/08	914.5–915.0	Regional groundwater
R-43	CASA-08-14143	9/10/08	954.5–955.0	Regional groundwater
R-43	CASA-08-14144	9/10/08	974.5–975.0	Regional groundwater
R-43	CASA-08-14145	9/10/08	992.5–993.0	Regional groundwater
R-43	CASA-08-14146	9/10/08	1005.5–1006.0	Regional groundwater
Well Development				
SCI-2	CASA-08-14155	8/13/08	549–599	Pump, perched groundwater
SCI-2	CASA-08-14156	8/13/08	549–599	Pump, perched groundwater
SCI-2	CASA-08-14157	8/14/08	559–599	Pump, perched groundwater
SCI-2	CASA-08-14158	10/3/08	547–567	Pump, perched groundwater
SCI-2	CASA-08-14159	10/6/08	547–567	Pump, perched groundwater
SCI-2	CASA-08-14160	10/9/08	547–567	Pump, perched groundwater
R-43 (upper)	CASA-08-14161	10/27/08	920.6	Pump, regional groundwater
R-43 (upper)	CASA-08-14162	10/27/08	908.6	Pump, regional groundwater
R-43 (upper)	CASA-08-14163	10/27/08	902.5	Pump, regional groundwater
R-43 (upper)	CASA-08-14164	10/27/08	902.5	Pump, regional groundwater
R-43 (upper)	CASA-08-14165	10/27/08	902.5	Pump, regional groundwater

Table 4.2-1 (continued)

Location ID	Sample ID	Date Collected	Collection Depth (ft bgs)	Sample Type
Well Development				
R-43 (lower)	CASA-08-14166	10/29/08	975.8	Pump, regional groundwater
R-43 (lower)	CASA-08-14167	10/29/08	966.1	Pump, regional groundwater
R-43 (lower)	CASA-08-14168	10/29/08	966.1	Pump, regional groundwater
R-43 (lower)	CASA-08-14169	10/29/08	966.1	Pump, regional groundwater
R-43 (lower)	CASA-08-14170	10/29/08	966.1	Pump, regional groundwater
R-43 (lower)	CASA-08-14171	10/30/08	966.1	Pump, regional groundwater
Aquifer Pump Test				
R-43 (upper)	GW-09-969	11/03/08	905.4	Pump, regional groundwater
R-43 (upper)	GW-09-970	11/03/08	905.4	Pump, regional groundwater
R-43 (upper)	GW-09-971	11/03/08	905.4	Pump, regional groundwater
R-43 (upper)	GW-09-972	11/03/08	905.4	Pump, regional groundwater
R-43 (upper)	GW-09-973	11/03/08	905.4	Pump, regional groundwater
R-43 (upper)	GW-09-974	11/03/08	905.4	Pump, regional groundwater
R-43 (upper)	GW-09-975	11/03/08	905.4	Pump, regional groundwater
R-43 (upper)	GW-09-976	11/03/08	905.4	Pump, regional groundwater
R-43 (upper)	GW-09-977	11/03/08	905.4	Pump, regional groundwater
R-43 (upper)	GW-09-978	11/04/08	905.4	Pump, regional groundwater
R-43 (upper)	GW-09-979	11/04/08	905.4	Pump, regional groundwater
R-43 (upper)	GW-09-980	11/04/08	905.4	Pump, regional groundwater
R-43 (upper)	GW-09-981	11/04/08	905.4	Pump, regional groundwater
R-43 (lower)	GW43-09-982	11/08/08	963.2	Pump, regional groundwater
R-43 (lower)	GW43-09-983	11/08/08	963.2	Pump, regional groundwater
R-43 (lower)	GW43-09-984	11/08/08	963.2	Pump, regional groundwater
R-43 (lower)	GW43-09-985	11/08/08	963.2	Pump, regional groundwater
R-43 (lower)	GW43-09-986	11/08/08	963.2	Pump, regional groundwater
R-43 (lower)	GW43-09-987	11/08/08	963.2	Pump, regional groundwater
R-43 (lower)	GW43-09-988	11/08/08	963.2	Pump, regional groundwater
R-43 (lower)	GW43-09-989	11/08/08	963.2	Pump, regional groundwater
R-43 (lower)	GW43-09-990	11/08/08	963.2	Pump, regional groundwater
R-43 (lower)	GW43-09-991	11/09/08	963.2	Pump, regional groundwater
R-43 (lower)	GW43-09-992	11/09/08	963.2	Pump, regional groundwater
R-43 (lower)	GW43-09-993	11/09/08	963.2	Pump, regional groundwater
R-43 (lower)	GW43-09-994	11/09/08	963.2	Pump, regional groundwater

Table 6.0-1
SCI-2 and R-43 Video and Geophysical Logging Runs

Borehole ID	Date	Depth (ft)	Description
SCI-2	7/30/08	surf–875	LANL natural gamma-ray tool , indicated core barrel from 798–805 ft bgs
	8/1/08	surf–660: video and gamma ray 422–660: induction	LANL video, induction, and natural gamma ray. Video log indicated fractured basalt intervals flowing water (509.4, 546, and 546.5 ft bgs), top of water in hole (590 ft bgs), and top of cut-off HQ pipe (659.5 ft bgs).
	9/2/08	surf–575	LANL natural gamma-ray tool, indicated sand pack top at 527 ft bgs
R-43	8/27/08	surf–790	Run LANL natural gamma-ray, induction, and video tools. Video shows hole through basalt with only trace water entering borehole at 634 ft bgs. Induction run to 790 ft bgs (in open hole) with conductivity spikes at 685, 662, and 651 ft bgs. Gamma-ray run to 787 ft bgs, shows base Cerros del Rio basalt at 631.5 ft bgs.
	9/12/08	surf–1005.7	Run LANL natural gamma-ray tool to 1005.7 ft bgs
	10/6/08	surf–290	Run LANL video tool to inspect top of tremie pipe (at 135 ft bgs) and fishing spear grab into same
	10/7/08	surf–135	Run LANL video tool to guide placement of overshot tool on tremie pipe at 135 ft bgs
	10/16/08	surf–282	Run LANL video tool to check on cement top inside 16-in. casing—unsuccessful due to cement “foam” occluding view

Table 7.2-1
SCI-2 and R-43 Annular Fill Materials

Borehole ID	Material	Volume
SCI-2	Surface seal: cement slurry	26.6 ft^3
	Bentonite seal: high solids bentonite grout	70.0 ft^3
	Bentonite seal: bentonite chips	3.5 ft^3
	Bentonite seal: bentonite pellets	3.5 ft^3
	Primary filter: 10/20 silica sand	3.5 ft^3
	Backfill material: bentonite chips and pellets	18.9 ft^3
	Potable water used in the intermediate aquifer (drilling and well construction)	16,096 gal.
R-43	Surface seal: cement slurry	391.3 ft^3
	Bentonite seal: bentonite chips	191.5 ft^3
	Bentonite seal: high solids bentonite grout	279.4 ft^3
	Bentonite seal (upper): bentonite chips	18.4 ft^3
	Upper fine sand collar: 20/40 silica sand	2.0 ft^3
	Upper filter: 10/20 silica sand	31.0 ft^3
	Bentonite seal (mid): bentonite chips	13.4 ft^3
	Lower fine sand collar: 20/40 silica sand	2.0 ft^3
R-43	Lower filter: 10/20 silica sand	13.5 ft^3
	Bentonite seal (lower):	11.1 ft^3
	Backfill material: slough	est. 4.5 ft^3
	Potable water used in the regional aquifer (drilling and well construction)	40,915 gal.

Table 8.5-1
SCI-2 and R-43 Survey Coordinates

North	East	Elevation	Identification
1769651.16	1637155.34	6735.70	SCI-2 brass pin embedded in pad
1769648.66	1637156.2	6735.85	SCI-2 ground surface near pad
1769646.50	1637157.76	6738.93	SCI-2 top of 10-in. protective casing
1769646.24	1637157.45	6738.54	SCI-2 top of stainless-steel well casing
1769614.70	1637236.21	6732.65	R-43 brass pin embedded in pad
1769606.05	1637242.02	6732.54	R-43 ground surface near pad
1769609.60	1637237.06	6736.18	R-43 top of 10-in. protective casing
1769609.17	1637237.17	6735.33	R-43 top of stainless-steel well casing

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

Table 8.6-1
Summary of Waste Samples Collected during Drilling and Development of SCI-2 and R-43

Location ID	Sample ID	Date Collected	Description	Sample Type
SCI-2	GW53-08-14835	08/13/08	Oil-contaminated soil	New Mexico special waste (NMSW) solid
SCI-2	GW53-08-14836	08/13/08	Oil-contaminated soil	NMSW solid
SCI-2	RC05-08-15330	08/28/08	Purged water	liquid
SCI-2	RC05-08-15331	08/28/08	Purged water	liquid
SCI-2	RC05-08-15332	08/28/08	Purged water	liquid
SCI-2	RC05-08-15333	08/28/08	Purged water	liquid
R-43	RC53-08-15252	08/26/08	Oil-contaminated soil	NMSW solid
R-43	RC53-08-15253	08/26/08	Oil-contaminated soil	NMSW solid
R-43	RC53-08-15254	08/26/08	Oil-contaminated soil	NMSW solid
R-43	RC05-08-15248	10/29/08	Drilling fluid	liquid
R-43	RC05-08-15249	10/29/08	Drilling fluid	liquid
R-43	RC05-08-15250	10/29/08	Drilling fluid	liquid
R-43	RC05-08-15251	10/29/08	Drilling fluid	liquid
R-43	RC05-08-15349	10/29/08	Drill cuttings	solid
R-43	RC05-08-15350	10/29/08	Drill cuttings	solid
R-43	RC05-08-15279	11/05/08	Purged water	liquid
R-43	RC05-08-15280	11/05/08	Purged water	liquid
R-43	RC05-08-15281	11/05/08	Purged water	liquid
R-43	RC05-08-15282	11/05/08	Purged water	liquid

Appendix A

Core Hole SCI-2 and Borehole R-43 Lithologic Logs

Los Alamos National Laboratory
Regional Hydrogeologic Characterization Project
Borehole Lithologic Log

CORE HOLE IDENTIFICATION (ID): SCI-2	**TECHNICAL AREA (TA): 72**	**PAGE:** 1 of 5
DRILLING COMPANY: Boart Longyear Company	**START DATE/TIME:**	**END DATE/TIME:**
DRILLING METHOD: Rotosonic Core, Wireline Core	**MACHINE**: Rotosonic Core RIg	**SAMPLING METHOD:** Core
GROUND ELEVATION:		**TOTAL DEPTH (TD):** 890 ft below ground surface (bgs)
DRILLERS: D. Osterberg/M. Cross	**SITE GEOLOGIST:** A. Miller, J. R. Lawrence	

DEPTH (ft bgs)	LITHOLOGY	LITHOLOGIC SYMBOL	NOTES
0–37.0	**ALLUVIUM:** Tuffaceous and volcaniclastic sediments—light gray (7.5YR 7/1) to pinkish gray (7.5YR 6/2) predominantly unconsolidated silt and minor clay with fine sand made up of weathered tuff materials; includes locally occurring coarse gravel composed of indurated tuff and dacite; poorly sorted.	Qal	Alluvium (0–37.0 ft bgs) is 37 ft thick. Qal/Qbt 1g contact estimated at 37 ft bgs. Rotosonic coring technique was used from surface to 417 ft bgs.
37.0–65.5	**UNIT 1g, TSHIREGE MEMBER OF THE BANDELIER TUFF:** Ash-flow tuff (ignimbrite)—white (5YR 8/1), poorly to moderately welded, crystal-bearing, lithic-poor, pumiceous; phenocrysts of sanidine and quartz plus vitric pumice lapilli (up to 8 cm) in a matrix of glassy ash; locally contains minor small xenoliths of dacitic composition.	Qbt1g	Unit 1g, Tshirege Member of the Bandelier Tuff (37.0-77.0 ft bgs) is 38 ft thick. Qbt 1g/Qct contact estimated to be at 77 ft bgs.
65.5–77.0	Ash-flow tuff (ignimbrite)—reddish yellow (5YR 6/6) to white (5YR 8/1), poorly to moderately welded, crystal-bearing, lithic-poor, pumiceous, abundant sanidine and quartz phenocrysts with vitric pumice lapilli (up to 6 cm) set in a matrix of glassy ash, trace dacitic xenoliths inclusions.		
77.0–111.0	**CERRO TOLEDO INTERVAL:** Volcaniclastic and tuffaceous sediments—brown (7.5YR 5/3) to reddish brown (2.5YR 5/4), unconsolidated, fine to coarse sand and gravelly sand, composed of detrital quartz, sanidine, pumice and dacite, subangular clasts from sand-sized grains to small cobbles (up to 7 cm), poorly sorted.	Qct	Cerro Toledo interval (77.0–111.0 ft bgs) is 34 ft thick. Qct/Qbo contact not preserved in core; estimated to be at 111.0 ft bgs.

Borehole Lithologic Log (continued)

BOREHOLE ID: SCI-2	**TA:** 72		**PAGE:** 2 of 5
DEPTH (ft bgs)	LITHOLOGY	LITHOLOGIC SYMBOL	NOTES
111.0–327.0	**OTOWI MEMBER OF THE BANDELIER TUFF:** Ash-flow tuff (ignimbrite)—pale red (2.5YR 7/2) to pinkish gray (5YR 6/2), poorly welded, crystal-bearing, lithic-rich, strongly pumiceous; abundant white to orange-brown (5YR 6/6) vitric pumice lapilli (up to 2 cm), dacitic and andesitic xenolithic inclusions (0.5 cm to 3 cm) plus quartz and sanidine phenocrysts in a matrix of fine glassy volcanic ash.	Qbo	Otowi Member (111.0–327.0 ft bgs), 216 ft thick. Qbo/Qbog contact not preserved in core, estimated at 327 ft bgs.
327.0–350	**GUAJE PUMICE BED:** Pumice-fall tuff—white (5YR 8/1) poorly consolidated pumice-rich layer composed predominantly of white vitric pumice lapilli and fragments (up to 23 mm) with minor glassy volcanic ash; small dacite lithic fragments (1 mm to 3 mm) locally present.	Qbog	Guaje Pumice (327.0–350 ft bgs) is 22 ft thick; lower contact not preserved in core.
350–367.0	**UPPER PUYE FORMATION:** Volcaniclastic sediments—reddish brown (5YR 5/3), moderately to weakly consolidated, siltstone, sandstone and fine- to coarse-conglomeratic sandstone; subangular to subrounded gravel clasts (up to 35 mm) composed predominantly of coarsely porphyritic dacite, reddish brown rhyolite and minor white pumice fragments (up to 4 mm).	Tpf	Puye Formation, upper interval (350–396 ft bg) is 46 ft thick; the Tpf/Tb 4 contact is gradational.
367.0–386.0	Volcaniclastic sediments—reddish brown (5YR 5/3), siltstone with very fine-grained sand with up to 3% dacite granules and small subangular pebbles.		
386.0–396	Volcaniclastic sediments/basalt rubble—reddish brown (5YR 4/4) siltstone with very fine sand containing weathered angular basalt fragments that increase in frequency and size downward in the interval. Black (5YR 2/1) cobble- and boulder-size vesicular basalt fragments occur in a matrix of silt, likely representing the rubbly top of a lava flow.		
396–421.7	**CERROS DEL RIO BASALT:** Basalt lava—dark olive gray (5Y 3/2), strongly vesicular, vesicles up to 5 mm in diameter; basalt is porphyritic with an aphanitic groundmass, phenocrysts 3%–6% by volume of olivine (ol) >clinopyroxene (cpx) and minor plagioclase; interval locally fractured.	Tb4	Cerros del Rio basalt (396–692.2 ft bgs) is 233 ft thick. Conventional wireline coring technique was used from 417 ft bgs to borehole TD at 490.0 ft bgs.

Borehole Lithologic Log (continued)

BOREHOLE ID: SCI-2	**TA:** 72		**PAGE:** 3 of 5
DEPTH (ft bgs)	LITHOLOGY	LITHOLOGIC SYMBOL	NOTES
421.7–455.5	Basalt lava—very dark grayish brown (2.5Y 3/2), moderately vesicular, porphyritic with aphanitic groundmass; phenocrysts 3%–5% by volume of ol>cpx>plagioclase with occurrences of cumulophyric ol-cpx, light tan clay locally filling vesicles and coating fracture surfaces.	Tb4	
455.5–547.0	Basalt lava—dark olive gray (5Y 3/2), massive, generally nonvesicular, porphyritic with aphanitic groundmass; phenocrysts 3%–6% by volume of ol>cpx and minor plagioclase with common occurrences of dark opaque clinopyroxene reaction rims on olivine; local fractures lined with light tan clay. Sharply increased degree of vesicularity at 546.3–547.0 ft bgs.		
547.0–629.2	Basalt lava—dark reddish brown (5YR 3/3) to dark olive gray (5Y 3/2), strongly vesicular at 547.0–561.0 ft bgs to massive becoming nonvesicular below 561.0 ft bgs; basalt is porphyritic with aphanitic groundmass, phenocrysts (4%–7% by volume) composed of ol>plagioclase>cpx; cumulophyric clusters of intergrown olivine and plagioclase noted. The likely top of an individual basalt flow unit at about 547.0 ft is suggested by (1) abrupt increase in vesicularity, (2) apparent compositional change with increased abundances of phyric plagioclase, and (3) a distinct zone of broken, rubbly core with abundant white clay from 547.0 to 550.9 ft bgs.		Strong vesicularity indicates likely top of individual basalt flow unit at about 547.0 ft bgs; upper contact indistinct but indicated as a zone of clayey rubble at 547.0–550.9 ft bgs. Lower contact at 629.2 ft bgs.
629.2–635.5	**LOWER PUYE FORMATION:** Volcaniclastic sediments—reddish brown (2.5YR 5/4) siltstone and silty very fine-grained sandstone with 15%–20% pebble gravel, subangular clasts predominantly of dacite; also contains dark reddish brown (2.5YR 3/6) fine-grained basaltic sandstone (oxidized) of possible hydromagmatic origin.	Tpf	Puye Formation, lower interval, (629.2–827.0 ft bgs) is 197.8 ft thick. Less than 10% core recovery for interval 629.2–635.5 ft bgs.
635.5–705.5	Volcaniclastic sediments—reddish gray (2.5YR 6/1) coarse conglomerate with silty fine-grained sandy matrix, cored dacite cobbles and boulders, trace pumice; weakly cemented.		Poor core recovery (approximately 10%) for interval 635.5–705.5 ft bgs
705.5–715.5	Volcaniclastic sediments—No core recovery.		
715.5–745.5	Volcaniclastic sediments—gray (5YR 6/1) to dark reddish brown (5YR 2.5/2) coarse conglomerate, well cemented, local fractures coated with clay; cored dacite cobbles and boulders.		

Borehole Lithologic Log (continued)

BOREHOLE ID: SCI-2		**TA** 72	**PAGE:** 4 of 5
DEPTH (ft bgs)	**LITHOLOGY**	**LITHOLOGIC SYMBOL**	**NOTES**
745.5–765.5	Volcaniclastic sediments—No core recovery.	Tpf	
765.5–827.0	Volcaniclastic sediments—dark reddish brown (5YR 2.5/2) to pink (5YR 7/3) coarse conglomerate, poorly to well cemented, local near-horizontal fractures, subangular gravel clasts; trace pumice grains.		
827.0–845.5	**MIIOCENE PUMICEOUS DEPOSITS:** Pumiceous sediments—black (5Y 2.5/1) siltstone with very fine-grained sand and pebble conglomerate containing 10%–20% sand-size to pebble-size (up to 10 mm) fragments of white glassy pumice and minor clasts of gray porphyritic dacite.	Tjfp	Drilled interval of Miocene Pumiceous deposits (827.0–890.0 ft bgs) is 63 ft thick.
827.0–845.5	Pumiceous sediments—No core recovery.		
845.5–859.5	Pumiceous sediments—light brown (7.5Y 6/3) silty sand and pumiceous conglomerate, containing 15%–25% white vitric pumice lapilli and abundant detrital dacite of grain-size to small pebbles, unconsolidated to weakly cemented, trace clay.		
859.5–865.5	Pumiceous sediments—No core recovery.		
865.5–890.0	Pumiceous sediments—reddish yellow (5YR 6/6) silty very fine-grained tuffaceous sand and pumiceous conglomerate containing 20%–30% white vitric pumice lapilli and fragments (up to 4 cm); dacite and minor vitrophyre occurring as sand-sized grains. Abundance of detrital pumice increases markedly with depth, making up as much as 85%–90% by volume with 10%–15% dacite and vitrophyre granules and small pebbles in discrete clast-supported intervals from 885.0 to 890.0 ft bgs. The interval from 887.1 to 890 ft is a clast-supported primary fall.		Total SCI-2 borehole depth: 890.0 ft bgs.

Borehole Lithologic Log (continued)

ABBREVIATIONS

5YR 8/1 = Munsell soil color notation where hue (e.g., 5YR), value (e.g., 8), and chroma (e.g., 1) are expressed. Hue indicates soil color's relation to red, yellow, green, blue, and purple. Value indicates soil color's lightness. Chroma indicates soil color's strength.

Qal = Quaternary alluvium.

Qbo = Otowi Member of Bandelier Tuff.

Qbog = Guaje Pumice Bed.

Tb4 = Cerros del Rio basalt.

Tpf = Puye Formation.

Tsfu = Santa Fe Group.

Y = Yellow.

YR = Yellow red.

Los Alamos National Laboratory
Regional Hydrogeologic Characterization Project
Borehole Lithologic Log

COREHOLE IDENTIFICATION (ID): R-43	**TECHNICAL AREA (TA):** 72	**PAGE:** 1 of 11
DRILLING COMPANY: Boart Longyear	**START DATE/TIME:** 8/12/08: 1420	**END DATE/TIME:** 9/10/08: 1410
DRILLING METHOD: Dual Rotary	**MACHINE**: Foremost DR24 HD	**SAMPLING METHOD:** Grab
GROUND ELEVATION:		**TOTAL DEPTH:** 1006 ft below ground surface (bgs)
DRILLERS: J. Staloch/J. Bowen	**SITE GEOLOGIST:** A. Miller, J. R. Lawrence	

DEPTH (ft bgs)	LITHOLOGY	LITHOLOGIC SYMBOL	NOTES
620–630	**CERROS DEL RIO BASALT:** Basalt—light gray (GLEY1 7/1) massive, porphyritic with aphanitic groundmass. 620–625 ft +10F: phenocrysts (3%–5% by volume) of dark brown opaque clinopyroxene (anhedral, resorbed) and lesser pale green olivine (locally with cpx rims); groundmass appears to be weakly altered; trace white clay. 625–630 ft +10F: composition similar to above, apparent bleaching and associated alteration of groundmass.	Tb4	Drill cuttings collected for microscopic analysis at 5-ft intervals from 620 ft bgs to borehole TD at 1006 ft bgs.
630–635	**LOWER PUYE FORMATION:** Basalt/volcaniclastic sediments—mixed basalt chips (angular) and subangular detrital clasts made up of various volcanic rocks. +10F: 70%–80% gray (GLEY 6/0) broken basalt chips similar in composition to 620–625 ft; 20%–30% orange (7.5YR 7/6) to light pinkish gray (7.5YR 7/2) pebble gravel made up of volcanic (rhyolite, dacite) clasts exhibiting some rounding due to fluvial transport. First appearance of detrital sedimentary constituents.	Tpf	Estimated Tb4/Tpf contact at 630 ft bgs. Lower Puye Formation (630-834 ft bgs) estimated to be 204 ft thick.
635–640	**LOWER PUYE FORMATION:** Volcaniclastic sediments—mixed subrounded felsic volcanic detrital clasts and broken basalt chips. +10F: 60%–70% pale pink-yellow (7.5YR 8/6) pebble gravel, clasts of rhyolite to rhyodacite and fragments of tuffaceous sandstone, pebbles (up to 8 mm) commonly rounded; 30%–40% chips of olivine basalt.	Tpf	
645–655	Volcaniclastic sediments—no sample available for description.		Lost circulation; no sample collected.

Borehole Lithologic Log (continued)

BOREHOLE ID: R-43	**TA:** 72		**PAGE:** 2 of 11
DEPTH (ft bgs)	LITHOLOGY	LITHOLOGIC SYMBOL	NOTES
655–675	Volcaniclastic sediments—white (7.5YR 8/1) clayey sand with gravel, subangular to subrounded clasts composed of intermediate volcanic rocks (predominantly dacite). 655–660 ft WR: abundant white clay matrix. +10F: subangular to subrounded detrital clasts (up to 15 mm) composed dominantly of light gray (GLEY1 7/0) hornblende-dacite, rhyolite and unidentified white aphanitic volcanic rock. 660–670 ft WR: abundant white (7.5YR 8/1) clay matrix. +10F: subangular to subrounded detrital clasts (up to 22 mm) dominantly gray (GLEY1 7/0) dacite and minor white aphanitic dacite(?). 670–675 ft + WR: abundant white (7.5YR 8/1) clay matrix. +10F: subangular grains and pebbles (up to 22 mm) composed of light gray (GLEY1 7/0) to pink dacites.	Tpf	
675–680	Volcaniclastic sediments—pinkish white (7.5YR 8/2), gravel with sand and clay, dacitic detritus. + WR: moderately abundant white (7.5YR 8/1) clay matrix. +10F: subangular grains and pebbles (up to 15 mm) composed mostly of hornblende dacite.		
680–695	Volcaniclastic sediments—pinkish white (7.5YR 8/2) pebble gravel with sand, dacitic detritus. 680–690 ft +10F: subangular to subrounded granules and pebbles (up to 13 mm) composed of gray porphyritic dacite, trace white aphantic dacite. Nearly monolithologic sample. 690–695 ft +10F: subrounded detrital granules and pebbles composed of light gray hornblende-dacite, minor white aphantic rhyodacite(?).		
695–710	Volcaniclastic sediments—pinkish white (7.5YR 8/2), gravel with sand and silt, dacitic detritus. 695–700 ft +10F: subangular detrital granules and pebbles (up to 15 mm) dominantly of gray (GLEY1 6/0) hornblende-dacite; 1%–2% dark gray dacitic vitrophyre (glassy); minor white aphantic rhyodacite. 700–710 ft +10F: subangular detritus, pebbles (up to 15 mm); 90% light gray (GLEY1 7/0) porphyritic hbn-dacite; 10% biotite-rhyodacite plus white aphanitic rhyodacite and minor vitrophyre.		

Borehole Lithologic Log (continued)

BOREHOLE ID: R-43	**TA:** 72		**PAGE:** 3 of 11
DEPTH (ft bgs)	LITHOLOGY	LITHOLOGIC SYMBOL	NOTES
710–735	Volcaniclastic sediments—pinkish white (7.5YR 8/2), gravel with sand, dacitic detritus. 710–715 ft +10F: subangular detrital granules and pebbles (up to 15 mm), 99% light gray (GLEY1 7/0) porphyritic hbn-dacite, minor biotite-dacite. 715–720 ft +10F: detrital granules and pebbles (up to 16 mm), composed of light gray (GLEY1 7/0) hbn-dacite and white to pinkish biotite-dacite. 720–730 ft +10F: subangular and broken detrital clasts (up to 15 mm) composed of light gray (GLEY1 7/0) to pink (5YR 7/4) dacites (hornblende- and biotite-bearing varieties) and trace vitrophyric dacite. 730–735 ft +10F: subangular and broken clasts (up to 11 mm), composed of light gray (GLEY1 7/0) and light reddish brown (5YR 6/4) varieties of porphyritic dacite.	Tpf	
735–740	Volcaniclastic sediments—white (5YR 8/1), gravel with sand (fines >15%), dacitic detritus. 735–740 ft +10F: subangular and broken clasts (up to 10 mm), predominantly of light gray (GLEY1 7/0) hornblende-dacite, trace dacitic vitrophyre.		
740–755	Volcaniclastic sediments—no sample available for description.		740–755 ft lost circulation; no sample collected.

Borehole Lithologic Log (continued)

BOREHOLE ID: R-43	**TA:** 72		**PAGE:** 4 of 11
DEPTH (ft bgs)	LITHOLOGY	LITHOLOGIC SYMBOL	NOTES
755–785	<u>Volcaniclastic sediments</u>—pinkish white (5YR 8/2), fine to coarse gravel with sand, dacitic detritus. 755–760 ft +10F: subangular and broken clasts (up to 25 mm), composed almost entirely of light gray (GLEY1 7/0) coarsely porphyritic hornblende-dacite, trace dacitic vitrophyre. 760–765 ft +10F: subangular and broken clasts (up to 30 mm), composed of light gray (GLEY1 7/0) porphyritic hornblende-dacite and white to pinkish biotite-dacite. 765–770 ft +10F: subangular to subrounded and broken clasts composed almost entirely of light gray to pinkish porphyritic dacite. 770–775 ft +10F: subangular to subrounded and broken clasts (up to 17 mm), composed of light gray (GLEY1 7/0) to pinkish hornblende-dacite with lesser amounts of white (5YR 8/1) biotite-rhyodacite(?). 775–780 ft +10F: subangular and broken detrital clasts composed of hornblende- and biotite-bearing dacite. 780–785 ft +10F: abundant broken clasts (up to 22 mm), composed hornblende-and biotite-dacites.	Tpf	
785–795	<u>Volcaniclastic sediments</u>—pinkish white (5YR 8/2), pebble gravel with sand, dacitic detritus. 785–790 ft +10F: subangular and subrounded granules and pebbles (up to 10 mm), composed of light gray (GLEY1 7/0) porphyritic hornblende-dacite and white biotite-dacite, trace dacitic vitrophyre. 790–795 ft +10F: subangular to subrounded detrital clasts of light gray (GLEY1 7/0) porphyritic hbn-dacite and lesser white biotite-rhyodacite(?), minor porphyritic vitrophyre.		
795–805	<u>Volcaniclastic sediments</u>—pinkish tan (5YR 7/3), clayey gravel with sand (fines 15%–20%), dacitic detritus. 795–800 ft +10F: subrounded to subangular detrital clasts predominantly of light gray (GLEY1 7/0) hornblende-dacite and lesser biotite-dacite, also minor amounts of biotite rhyodacite(?). 800–805 ft +10F: subrounded pebbles (up to 10 mm) of light gray (GLEY1 7/0) to white hornblende- and biotite-bearing varieties of dacite.		

Borehole Lithologic Log (continued)

BOREHOLE ID: R-43	**TA** 72		**PAGE:** 5 of 11
DEPTH (ft bgs)	LITHOLOGY	LITHOLOGIC SYMBOL	NOTES
805–815	Volcaniclastic sediments—pinkish tan (5YR 7/3), clayey sand with gravel (fines 15%–20%), dacitic detritus. 805–810 ft +10F: subrounded to subangular detrital clasts (up to 18 mm) predominantly coarsely porhyritic dacite plus minor white aphanitic dacite. 810–815 ft +10F: very small sample volume; clasts composed entirely of light gray porphyritic dacites. Trace glassy pumices noted in +35F.	Tpf	
815–830	Volcaniclastic sediments—pale pink (5YR 8/3), gravel with sand, dacitic detritus. 815–825 ft +10F: subangular to subrounded granules and pebbles (up to 10 mm) composed of light gray (GLEY1 7/0) coarsely porhyritic dacite and minor white aphanitic dacite. 825–830 ft +10F: clasts composed of roughly equal percentages light gray (GLEY1 7/0) porphyritc dacite and white (5YR 8/1) aphanitic dacite; minor biotite-bearing rhyodacite(?).		
830–834	Volcaniclastic sediments/pumiceous sediments—pinkish tan (5YR 8/3), gravel with sand, mixed dacitic and minor pumice detrital constituents. +10F: subangular to subrounded clasts (up to 10mm) composed of 97-98% light gray (GLEY1 7/0) and white dacites; 2-3% fragments of white vitric pumice. First appearance of glassy pumices as a significant constituent.		
834–840	**MIOCENE PUMICEOUS SEDIMENTS:** Pumiceous sediments—varicolored pinkish tan (5YR 8/3) and light gray (GLEY1 7/0), sand with pebble gravel, mixed pumice and dacitic detrital constituents. +10F: 60%–70% fragments of aphyric pinkish glassy pumice; 30%–40% varieties of dacite, flow-banded rhyolite(?) and dark colored vitrophyre. Vitrophyre abundant in +35F.	Tjfp	Miocene Pumiceous sediments (834–906 ft bgs) estimated 71 ft thick. Upper contact with overlying Tpf estimated at 834 ft bgs.

Borehole Lithologic Log (continued)

BOREHOLE ID: R-43	**TA** 72	**PAGE:** 6 of 11

DEPTH (ft bgs)	LITHOLOGY	LITHOLOGIC SYMBOL	NOTES
840–850	Pumiceous sediments—pale yellowish tan (10YR 8/4) fine to coarse sand with pebble gravel, pumice and minor volcanic detritus. 840–845 ft +10F: 98% fragments of glassy white pumice, weakly porphyritic to aphyric; 1%–2% very dark gray (GLEY1 3/0) basaltic(?) vitrophyre. 845–850 ft +10F: 98% fragments (up to 23 mm) of glassy white pumice; 2% clasts of basaltic vitrophyre and rhyolite. +35F: abundant fragments of very fine-grained volcaniclastic sandstone.	Tjfp	
850-865	Pumiceous sediments—varicolored pale yellowish tan (10YR 8/4) and gray (GLEY1 6/0) fine sand with pebble gravel, pumice and volcanic detritus. 850–855 ft +10F: subrounded clasts (up to 15 mm) composed of 40%–50% white glassy pumice fragments; 40%–50% volcanic constituents (basalt vitrophyre, hornblende dacite). 855–860 ft +10F: 80-85% pumice fragments; 15%–20% clasts of basalt vitrophyre and dacite. +35F: contains abundant fragments of very fine-grained volcaniclastic sandstone. 860–865 ft +10F: 95%–98% white vitric pumice fragments; 2%–5% subangular volcanic granules (up to 5 mm) composed of basalt vitrophyre and dacite.		
865-875	**Pumiceous sediments**—pale yellowish tan (10YR 8/4) fine sand with pebble gravel and silt/clay, pumice and volcanic detritus. 865–870 ft +10F: 75%–80% fragments of glassy white pumice; 10%–15% volcanic clasts (vitrophyre, dacite); 5%–10% fragments of very fine-grained volcanic/tuffaceous sandstone. 870–875 ft WR: abundant silty clay. +10F: 75%–80% white vitric pumice fragments; 20%–25% subangular volcanic clasts (dacite, vitrophyre); 3%–5% fragments of fine-grained tuffacaeous sandstone.		

Borehole Lithologic Log (continued)

BOREHOLE ID: R-43	**TA** 72		**PAGE:** 7 of 11
DEPTH (ft bgs)	LITHOLOGY	LITHOLOGIC SYMBOL	NOTES
875–895	Pumiceous sediments—pale yellowish brown (10YR 8/4) fine to medium sand with pebble gravel and silt/clay, pumice and volcanic detritus. 875–880 ft +10F: 98% fragments of aphyric white vitric pumice; 1%–2% granules and small pebbles of dacite and vitrophyre. 880–885 ft +10F: 85%–90% fragments of white vitric pumice, aphyric to very weakly porphyritic (biotite phenocrysts locally present); 10%–15% volcanic granules and small pebbles (dacite, basalt). 885–890 ft WR: silty matrix. +10F: 70%–75% fragments of aphyric white vitric pumice; 25%–30% volcanic detrital granules (dacite, flow-banded rhyodacite(?). 890–895 ft +10F: 98% fragments of aphyric white vitric pumice; 1%–2% volcanic granules (dacite, flow-banded rhyodacite or rhyolite).	Tjfp	
895–905	Pumiceous sediments—pale yellowish brown (10YR 8/4) fine to medium sand with pebble gravel and silt/clay, pumice and volcanic detritus. 895–900 ft +10F: 65-75% fragments of white vitric pumice; 10%–15% volcanic granules (predominantly dacite); 10%–20% fragments of fined-grained tuffaceous sandstone. 900–905 ft +10F: 40%–50% fragments of white vitric pumice with minor phenocrystic biotite; 15%–20% volcanic detritus (dacite, flow-banded rhyolite); 30%–40% fragments of fined-grained tuffaceous sandstone.		
905–910	**SANTA FE GROUP, UNDIVIDED:** Pumiceous sediments/volcaniclastic sediments—varicolored pinkish white (5YR 8/3) to gray (GLEY1 6/0) mixed volcanic, pumice and Precambrian detrital constituents. +10F: 15%–20% fragments of white vitric pumice; 30%–40% subrounded volcanic clasts (mostly dacite); 5%–10% rounded pC quartzite; 25%–35% fragments of fined-grained tuffaceous sandstone. +35F: abundant rounded sand grains of pC quartzite.	Tms/ Tsfch	Drilled upper part of the Hernandez Member of the Chamita Formation, Santa Fe Group (905–1006 ft bgs) estimated to be 101 ft thick. Upper contact with Miocene Pumiceous sediments (Tjfp) estimated at 905 ft bgs.

Borehole Lithologic Log (continued)

BOREHOLE ID: R-43	**TA** 72	**PAGE:** 8 of 11

DEPTH (ft bgs)	LITHOLOGY	LITHOLOGIC SYMBOL	NOTES
910–925	**HERNANDEZ MEMBER OF THE CHAMITA FORMATION, SANTA FE GROUP:** Volcaniclastic sediments—pinkish tan (5YR 6/3) silty fine to medium sand with gravel, mixed volcanic, pumice and Precambrian detrital constituents. 910–915 ft +10F: detrital clasts exhibit significant rounding, consist of 60%–70% volcanic rocks (dacite, rhyolite, andesite); 10%–20% Precambrian quartzite; 10%–15% pumice, 5%–10% indurated sandstone fragments. 915–920 ft +10F: rounded detrital clasts (up to 10 mm) consist of 35%–45% volcanic rocks (dacite, andesite); 5%–10% Precambrian lithologies (quartzite, granite); 50%–60% fragments of indurated medium-grained sandstone; 1%–2% pumice. 920–925 ft +10F: rounded detrital clasts consist of 20%–30% volcanic rocks (dacite, rhyolite); 10%–20% pC quartzite; 60%–70% fragments of indurated fine- to medium-grained sandstone.	Tsfch	
925–935	Volcaniclastic sediments—pinkish tan (5YR 8/3) pebble gravel with fine sand and silt, (fines 10%–15%), mixed volcanic and minor Precambrian detrital constituents. 925–930 ft +10F: 10%–15% subrounded volcanic clasts (predominantly dacite); up to 5% pC lithologies (quartzite, granite, occurring mainly in +35F); 75%–85% fragments of indurated fine- to medium-grained sandstone (i.e., conglomerate matrix). 920–935 ft +10F: 5-10% subrounded volcanic clasts (dacite); <1% pC lithologies (quartzite, granite, occurring more abundantly in +35F); 80%–90% fragments of indurated sandstone.		
935–940	Volcaniclastic sediments—pinkish tan (5YR 8/3) coarse gravel with medium to coarse snad, mixed volcanic and Precambrian detrital constituents. 935–940 ft +10F: 80%–90% subrounded and broken volcanic clasts (dacite, andesite); 5%–10% pC lithologies (quartzite, granite, microcline); trace pumice and indurated sandstone fragments.		

Borehole Lithologic Log (continued)

BOREHOLE ID: R-43	**TA** 72	**PAGE:** 9 of 11

DEPTH (ft bgs)	LITHOLOGY	LITHOLOGIC SYMBOL	NOTES
940–965	<u>Volcaniclastic sediments</u>—pinkish gray (5YR 7/2) silty coarse gravel with medium to coarse sand, broken and rounded clasts, mixed volcanic and lesser Precambrian detrital constituents. 940–945 ft +10F: rounded clasts (up to 22 mm) 90%–95% volcanic (predominantly dacite); 5%–10% quartzite. 945–950 ft +10F: 80%–90% volcanic lithologies (dacites); 5%–7% pC quartzites; 3%–5% indurated medium-grained sandstone fragments. 950–955 ft +10F: broken and subrounded clasts (up to 18 mm) consist of 90%–95% volcanic rocks (dacites); 5%–7% pC quartzites; trace pumice. 955–960 ft +10F: broken and subrounded clasts (up to 18 mm) made up of 80%–85% volcanic lithologies (dacites, flow-banded rhyolite); 10%–15% pC quartzites. 960–965 ft +10F: broken and subrounded to rounded clasts consisting of 75%–85% volcanic rocks (dacite, rhyodacite); 10-%–5% pC quartzites; 5%–7% indurated sandstone fragments.	Tsfch	
965–975	<u>Volcaniclastic sediments</u>—grayish brown (5YR 6/1) medium to coarse sand with gravel, mixed volcanic and lesser Precambrian detrital constituents. 965–970 ft +10F: rounded clasts (up to 15 mm) consisting of 85%–90% volcanic rocks (predominantly dacite); 10%–15% pC quartzites. 970–975’ ft +10F: clasts made up of 90%–95% volcanic rocks (predominantly dacite); 5%–7% pC quartzites.		

Borehole Lithologic Log (continued)

BOREHOLE ID: R-43	**TA** 72	**PAGE:** 10 of 11

DEPTH (ft bgs)	LITHOLOGY	LITHOLOGIC SYMBOL	NOTES
975–995	Volcaniclastic sediments—light grayish brown (5YR 6/1) medium to coarse sand with gravel and silt, mixed volcanic and Precambrian detrital constituents. 975–980 ft +10F: broken and rounded clasts (up to 22 mm) consisting of 80%–90% volcanic rocks (dacite, andesite); 10%–15% pC quartzites. 980–985 ft +10F: rounded clasts (up to 15 mm) made up of 90%–95% volcanic rocks (dacite, rhyolite, basalt); 2%–3% pC quartzites; 1%–2% indurated sandstone fragments. 985–990 ft +10F: broken and rounded clasts (up to 18 mm) consisting of 80%–85% volcanic rocks (dacite. rhyodacite); 15%–20% pC quartzites. 990–995 ft +10F: clasts made up of 70%–80% volcanic rocks (dacite, rhyodacite); 10%–15% pC quartzites; 5%–10% indurated sandstone fragments.	Tsfch	
995–1006	Volcaniclastic sediments—pinkish white (5YR 8/2) silty medium to fine sand with gravel, mixed volcanic and lesser Precambrian detrital constituents. 995–1000 ft +10F: broken and rounded clasts (up to 15 mm) consisting of 90%–95% volcanic rocks (predominantly dacite); 5%–7% pC rocks (quartzites, granite). 1000–1006 ft +10F: subrounded clasts (up to 15 mm) made up of 95%–97% volcanic rocks (dacite); 3%–5% pC quartzites.		Total R-43 borehole depth 1006 ft bgs.

Note: Lithologic log was completed from drill cuttings. The log does not include lithologic descriptions from surface to 620 ft bgs. For lithologies in the upper part of R-43, see lithologic log prepared for cores collected at adjacent corehole SCI-2.

Borehole Lithologic Log (continued)

ABBREVIATIONS

5YR 8/1 = Munsell soil color notation where hue (e.g., 5YR), value (e.g., 8), and chroma (e.g., 1) are expressed. Hue indicates soil color's relation to red, yellow, green, blue, and purple. Value indicates soil color's lightness. Chroma indicates soil color's strength.

cpx = Clinopyroxene.

GM = Groundmass.

ol = Olivine.

Qal = Quaternary alluvium.

Qbo = Otowi Member of Bandelier Tuff.

Qbog = Guaje Pumice Bed.

Tb4 = Cerros del Rio basalt.

Tpf = Puye Formation.

Tmps = Miocene Pumiceous sediments.

Y = Yellow.

YR = Yellow red.

+10F = Plus No. 10 sieve sample fraction.

+35F = Plus No. 35 sieve sample fraction.

Appendix B

Groundwater Analytical Results

B-1.0 SAMPLING AND ANALYSIS OF GROUNDWATER AT SCI-2

A total of seven groundwater samples were collected before well development (one sample) and during well development (six samples) at the perched intermediate depth well SCI-2. The samples were collected from the screen interval of 548.0 to 568.0 ft below ground surface (bgs) within the Cerros del Rio basalt. The filtered samples were analyzed for cations, anions, perchlorate, and metals. A total of 2585.5 gal. of groundwater was pumped from well SCI-2 during development.

B-1.1 Field Preparation and Analytical Techniques

Chemical analyses of groundwater-screening samples collected from well SCI-2 were performed at Los Alamos National Laboratory's (LANL's or the Laboratory's) Earth and Environmental Sciences Group 14 (EES-14). Groundwater samples were filtered (0.45-µm membranes) before preservation and chemical analyses. Samples were acidified at the EES-14 wet chemistry laboratory with analytical grade nitric acid to a pH of 2.0 or less for metal and major cation analyses.

Groundwater samples were analyzed using techniques specified in the U.S. Environmental Protection Agency SW-846 manual. Ion chromatography was the analytical method for bromide, chloride, fluoride, nitrate, nitrite, oxalate, perchlorate, phosphate, and sulfate. The instrument detection limit for perchlorate was 0.005 ppm. Inductively coupled (argon) plasma optical emission spectroscopy (ICPOES) was used for analyses of dissolved aluminum, barium, boron, calcium, total chromium, iron, lithium, magnesium, manganese, potassium, silica, sodium, strontium, titanium, and zinc. Dissolved aluminum, antimony, arsenic, barium, beryllium, boron, cadmium, cesium, chromium, cobalt, copper, iron, lead, lithium, manganese, mercury, molybdenum, nickel, rubidium, selenium, silver, thallium, thorium, tin, vanadium, uranium, and zinc were analyzed by inductively coupled (argon) plasma mass spectrometry (ICPMS). The precision limits (analytical error) for major ions and trace elements were generally less than ±7% using ICPOES and ICPMS. Concentrations of total organic carbon (TOC) in nonfiltered groundwater samples collected during well development were determined by using an organic carbon analyzer. Charge balance errors for total cations and anions were generally less than ±3% for complete analyses of the above inorganic chemicals. The negative cation-anion charge balance values indicate excess anions for the filtered samples. Total carbonate alkalinity was measured using standard titration techniques.

B-1.2 Field Parameters

Results of field parameters, consisting of pH, temperature, dissolved oxygen (DO), oxidation-reduction potential (ORP), specific conductance, and turbidity, measured during well development at SCI-2 are provided in Table B-1.2-1. Measurements of pH and temperature varied from 7.23 to 7.67 and from 14.1°C to 21.52°C, respectively, at well SCI-2. Temperature variability may have resulted from either a malfunctioning instrument or from the influence of land surface-atmosphere conditions on the measurements during sampling. Percent saturation of DO varied from 5.90 to 9.23. Perched intermediate depth groundwater at well SCI-2 is relatively oxidizing, based on DO and ORP measurements, with ORP varying from 185 to 216 millivolts (mV) (Table B-1.2-1). Most of the ORP readings measured at well SCI-2 were greater than +190 mV. Specific conductance ranged from 544 to 600 microsiemens per centimeter (µS/cm). Reliable (positive values) measurements of turbidity measured at well SCI-2 ranged from 0.6 to 7.8 nephelometric turbidity units (NTUs) for the nonfiltered groundwater samples. Several negative turbidity measurements were recorded at well SCI-2, which are considered to be unreliable, possibly resulting from improper instrument calibration and/or instrument malfunction. Only 1 of the 16 positive turbidity measurements recorded during well development exceeded 5 NTUs at the well (Table B-1.2-1).

B-1.3 Analytical Results for SCI-2 Groundwater-Screening Samples

Analytical results for groundwater-screening samples collected at well SCI-2 during drilling and well development are provided in Table B-1.3-1. Calcium and sodium are the dominant cations in perched intermediate depth groundwater pumped from well SCI-2. During well development, dissolved concentrations of calcium and sodium ranged from 57.6 to 63.7 ppm (57.6 to 63.7 mg/L) and from 20.2 to 23.1 ppm, respectively. Dissolved concentrations of chloride and fluoride varied from 47.4 to 58.1 ppm and from 0.17 to 0.20 ppm, respectively, during development (Table B-1.3-1). Dissolved concentrations of nitrate(N) and sulfate ranged from 3.68 to 4.38 ppm and from 77.0 to 91.4 ppm, respectively, at well SCI-2. Dissolved concentrations of chloride, nitrate(N), and sulfate significantly exceeded Laboratory background within perched intermediate depth groundwater (LANL 2007, 095817). Maximum background concentrations for dissolved chloride, nitrate plus nitrite(N), and sulfate for perched intermediate depth groundwater are 6.43 mg/L, 1.78 mg/L, and 34.8 mg/L, respectively (LANL 2007, 095817). Concentrations of TOC ranged from 1.49 to 2.43 mgC/L at well SCI-2 (Table B-1.3-1). The background concentration of TOC is 0.45 mgC/L (one sample) for perched intermediate depth groundwater (LANL 2007, 095817). Concentrations of perchlorate were less than detection (<0.005 ppm) at well SCI-2 (Table B-1.3-1). Elevated above-background concentrations of both nitrate(N) and TOC at well SCI-2 suggest the presence of contaminant plume consisting in part of treated sewage effluent most likely released from Technical Area 03 (TA-03) discharges.

Dissolved concentrations of iron were less than analytical detection (0.010 ppm) (10 μg/L, or 10 ppb) using ICPOES at well SCI-2. Dissolved concentrations of manganese ranged from 0.010 to 0.036 ppm (Table B-1.3-1), which exceeded the maximum background value of 3.63 μg/L for perched intermediate depth groundwater (LANL 2007, 095817). Dissolved concentrations of boron ranged from 0.023 to 0.037 ppm (Table B-1.3-1) at well SCI-2, which are all above the maximum background value of 18.0 μg/L for perched intermediate depth groundwater (LANL 2007, 095817). Dissolved concentrations of nickel ranged from 0.016 to 0.019 ppm (Table B-1.3-1) at well SCI-2, which is below the maximum background value of 29.0 μg/L for perched intermediate depth groundwater (LANL 2007, 095817). However, background mean and median concentrations of nickel in filtered samples are 3.04 and 0.50 μg/L, respectively, for perched intermediate depth groundwater (LANL 2007, 095817). Dissolved concentrations of zinc ranged from 0.003 to 0.005 ppm in groundwater-screening samples collected at SCI-2 (Table B-1.3-1). Background mean, median, and maximum dissolved concentrations of zinc are 3.21 μg/L, 0.75 μg/L, and 19.0 μg/L, respectively, for perched intermediate depth groundwater (LANL 2007, 095817). Total dissolved concentrations of chromium ranged from 0.497 to 0.689 ppm (497 to 689 μg/L) at well SCI-2 (Table B-1.3-1). Background mean, median, and maximum concentrations of total dissolved chromium are 0.86 μg/L, 0.50 μg/L, and 2.40 μg/L, respectively, for perched intermediate depth groundwater (LANL 2007, 095817). The most likely source of dissolved chromium measured in groundwater samples collected from well SCI-2 is from past releases associated with the TA-03 cooling towers, in which potassium dichromate was used as a corrosion inhibitor from 1956 to 1972. Chromate (CrO_4^{2-}) is mobile in groundwater under oxidizing and basic pH conditions characteristic of most perched intermediate saturated zones and the regional aquifer at Los Alamos.

B-2.0 SAMPLING AND ANALYSIS OF GROUNDWATER AT R-43

A total of 44 groundwater-screening samples were collected at R-43 screens 1 and 2 during drilling (7 samples), well development (11 samples), and aquifer performance (pumping) testing (26 samples). Thirteen groundwater samples were collected from each screen during aquifer performance testing. Groundwater samples collected from R-43 screens 1 and 2 were collected at depth intervals from 903.9 to 924.6 ft bgs and from 969.1 to 979.1 ft bgs, respectively. The filtered samples were analyzed for cations, anions, perchlorate, and metals. A total of 6677 gal. of groundwater was pumped from well R-43 during well development. An additional 12,001 gal. and 13,672 gal. of groundwater were pumped from screens 1 and 2, respectively, during the aquifer performance testing conducted at R-43.

B-2.1 Field Preparation and Analytical Techniques

Chemical analyses of groundwater-screening samples collected from well R-43 were performed at the EES-14 wet chemistry laboratory. Groundwater samples were filtered (0.45-µm membranes) before preservation and chemical analyses. Samples were acidified at the EES-14 wet chemistry laboratory with analytical grade nitric acid to a pH of 2.0 or less for metal and major cation analyses. The same analytical protocols and methods used for the SCI-2 samples were also followed for groundwater samples collected from well R-43 during drilling, well development, and aquifer performance testing. Perchlorate analyses are pending for groundwater samples collected from well R-43. Charge balance errors for total cations and anions for the R-43 samples were generally less than ±12%. The negative cation-anion charge balance values indicate excess anions for the filtered samples.

B-2.2 Field Parameters Measured during Well Development

Table B-2.2-1 provides the results of field parameters, consisting of pH, temperature, DO, ORP, specific conductance, and turbidity, measured during well development at well R-43. Measurements of pH and temperature varied from 8.37 to 9.22 and from 14.1°C to 22.3°C, respectively, at well R-43 during well development, with most of the temperature measurements warmer than 20°C. Percent saturation of DO varied from 41 to 73.8, suggesting that DO was measured between 2.99 and 5.38 mg/L at R-43 during well development. This assumes that 7.29 mg/L of DO represents complete (100%) saturation at 6000 ft and 20°C. Regional aquifer groundwater is relatively oxidizing at well R-43, based on DO and ORP measurements, with ORP varying from 76.2 to 185 mV (Table B-2.2-1). Most of the ORP readings taken during well development were greater than +110 mV. Specific conductance ranged from 175 to 212 µS/cm during well development at R-43. Values of turbidity measured at R-43 ranged from 0.7 to 85.4 NTUs for the nonfiltered groundwater samples. Forty-two of the 61 turbidity measurements recorded during well development exceeded 5 NTUs (Table B-2.2-1).

B-2.3 Field Parameters Measured During Aquifer Performance Testing

Results of field parameters, consisting of pH, temperature, DO, ORP, specific conductance, and turbidity, measured during aquifer performance testing at well R-43, are also provided in Table B-2.2-1. Measurements of pH and temperature varied from 8.21 to 9.18 and from 18.51°C to 21.6°C, respectively, at well R-43 during aquifer performance testing. Percent saturation of DO varied from 24.6 to 91.3, suggesting that DO was measured between 1.79 and 6.66 mg/L at R-43 during well development. This assumes that 7.29 mg/L of DO represents complete (100%) saturation at 6000 ft and 20°C. The ORP measurements substantially varied from –109 to 62.1 mV with negative, nonadjusted ORP values recorded for samples pumped from both screens (Table B-2.2-1). The ORP measurements taken during well development are considered to be more reliable than those taken during aquifer performance testing, based on percent saturation of DO and dissolved concentrations of nitrate(N) and sulfate. Specific conductance ranged from 174 to 202 µS/cm during aquifer performance testing at R-43. Reliable (positive values) measurements of turbidity measured at R-43 ranged from 0.1 to 73.1 NTUs for the nonfiltered groundwater samples (Table B-2.2-1).

B-2.4 Analytical Results for Groundwater-Screening Samples Collected during Well Development

Analytical results for groundwater-screening samples collected at well R-43 during both drilling and well development are provided in Table B-2.4-1. Calcium and sodium are the dominant cations in regional aquifer groundwater pumped from well R-43 screens 1 and 2. During well development of R-43 screen 1, dissolved concentrations of calcium and sodium ranged from 12.4 to 13.3 ppm and from 17.5 to 18.9 ppm, respectively (Table B-2.4-1). Dissolved concentrations of chloride and fluoride varied from 7.76 to 8.67 ppm and from 0.44 to 0.69 ppm, respectively, during development of this screen (Table B-2.4-1). Dissolved concentrations of nitrate(N) and sulfate ranged from 4.09 to 4.45 ppm and from 15.2 to 16.2 ppm, respectively, in the R-43 screen 1 samples. Dissolved concentrations of chloride, nitrate(N), and sulfate at well R-43 screen 1 exceeded Laboratory background for the regional aquifer (LANL 2007, 095817). Maximum background concentrations for dissolved chloride, nitrate plus nitrite(N), and sulfate in the regional aquifer are 5.95 mg/L, 1.05 mg/L, and 8.63 mg/L, respectively (LANL 2007, 095817). Concentrations of TOC ranged from 0.55 to 1.07 mgC/L at well R-43 screen 1 (Table B-2.4-1). The maximum background concentration of TOC is 1.37 mgC/L for the regional aquifer (LANL 2007, 095817). Elevated above-background concentrations of nitrate(N) at well R-43 screen 1 suggest the presence of contaminant plume consisting in part of treated sewage effluent most likely released from TA-03 discharges.

During well development of R-43 screen 1, dissolved concentrations of iron and manganese ranged from 0.32 to 1.14 ppm and from 0.009 to 0.019 ppm, respectively (Table B-2.4-1). The measured concentrations of dissolved iron most likely result from using a carbon-steel discharge pipe for sample collection at R-43 during well development and aquifer performance testing. Dissolved concentrations of iron exceeded the maximum background value of 147 μg/L for the regional aquifer; however, dissolved concentrations of manganese did not exceed the maximum background value of 124 μg/L (LANL 2007, 095817). Dissolved concentrations of boron ranged from 0.023 to 0.026 ppm (Table B-2.4-1) at well R-43 screen 1, which is below the maximum background value of 51.6 μg/L for the regional aquifer (LANL 2007, 095817). All dissolved concentrations of nickel were less than analytical detection (0.001 ppm, ICPMS) (Table B-2.4-1) in groundwater samples collected during both well development and aquifer performance testing at well R-43. Dissolved concentrations of zinc ranged from 0.001 to 0.021 ppm in groundwater-screening samples collected at R-43 screen 1 during well development (Table B-2.4-1). Background mean, median, and maximum concentrations of zinc in filtered samples are 3.08 μg/L, 1.45 μg/L, and 32.0 μg/L, respectively, for the regional aquifer (LANL 2007, 095817). Total dissolved concentrations of chromium ranged from 0.004 to 0.009 ppm (4 to 9 μg/L) at well R-43 screen 1 (Table B-2.4-1). Background mean, median, and maximum concentrations of total dissolved chromium are 3.07 μg/L, 3.05 μg/L, and 7.20 μg/L, respectively, for the regional aquifer (LANL 2007, 095817).

During well development of R-43 screen 2, dissolved concentrations of calcium and sodium ranged from 12.0 to 15.1 ppm and from 12.6 to 19.1 ppm, respectively (Table B-2.4-1). Dissolved concentrations of chloride and fluoride varied from 6.75 to 7.83 ppm and from 0.46 to 0.72 ppm, respectively, during development of this screen (Table B-2.4-1). Dissolved concentrations of nitrate(N) and sulfate ranged from 4.21 to 4.92 ppm and from 14.3 to 15.6 ppm, respectively, in the R-43 screen 2 samples (Table B-2.4-1). Dissolved concentrations of chloride, nitrate(N), and sulfate at well R-43 screen 2 exceeded Laboratory background for the regional aquifer (LANL 2007, 095817). Concentrations of TOC ranged from 0.60 to 1.76 mgC/L at well R-43 screen 2 (Table B-2.4-1). Elevated above-background concentrations of nitrate(N) and TOC at well R-43 screen 2 also suggest the presence of contaminant plume consisting in part of treated sewage effluent most likely released from TA-03 discharges.

During well development of R-43 screen 2, dissolved concentrations of iron and manganese ranged from 0.21 to 0.99 ppm and from 0.015 to 0.019 ppm, respectively (Table B-2.4-1). Dissolved concentrations of iron, influenced by corrosion of the carbon-steel discharge pipe, exceeded the maximum background value of 147 μg/L for the regional aquifer. Dissolved concentrations of manganese were below the maximum background value of 124 μg/L (LANL 2007, 095817). Dissolved concentrations of boron ranged from 0.020 to 0.056 ppm (Table B-2.4-1) at well R-43 screen 2, in which all but one of the samples are below the maximum background value of 51.6 μg/L for the regional aquifer (LANL 2007, 095817). Dissolved concentrations of zinc ranged from 0.004 to 0.012 ppm in groundwater-screening samples collected at R-43 screen 2 (Table B-2.4-1). Total dissolved concentrations of chromium slightly varied from 0.001 to 0.002 ppm (1 to 2 μg/L) at well R-43 screen 2 (Table B-2.4-1).

B-2.5 Analytical Results for Groundwater-Screening Samples Collected during Aquifer Performance Testing

Figure B-2.5-1 shows dissolved concentrations of calcium, chloride, total chromium, nitrate-N, sodium, and sulfate in groundwater samples collected from R-43 screens 1 and 2 during aquifer performance testing. Mixing of groundwater from both screens may have taken place during initial testing, based on similar concentrations of these solutes. During aquifer performance testing of R-43 screen 1, dissolved concentrations of calcium and sodium ranged from 11.8 to 15.5 ppm and from 11.4 to 15.5 ppm, respectively (Table B-2.4-1). Dissolved concentrations of chloride and fluoride varied from 6.05 to 9.17 ppm and from 0.47 to 0.56 ppm, respectively, during testing of this screen (Table B-2.4-1). Dissolved concentrations of nitrate(N) and sulfate ranged from 3.90 to 4.84 ppm and from 13.7 to 17.0 ppm, respectively, in the R-43 screen 1 samples (Table B-2.4-1). Dissolved concentrations of chloride, nitrate(N), and sulfate at well R-43 screen 1 continued to exceed Laboratory background for the regional aquifer (LANL 2007, 095817). Concentrations of TOC ranged from 0.75 to 0.95 mgC/L at well R-43 screen 1 during aquifer performance testing (Table B-2.4-1).

During aquifer performance testing of R-43 screen 1, dissolved concentrations of iron and manganese ranged from 0.66 to 1.26 ppm and from 0.015 to 0.024 ppm, respectively (Table B-2.4-1). Dissolved concentrations of manganese did not exceed the maximum background value of 124 μg/L (LANL 2007, 095817). Dissolved concentrations of boron ranged from 0.021 to 0.061 ppm (Table B-2.4-1) at well R-43 screen 1, in which all but one of the samples are below the maximum background value of 51.6 μg/L for the regional aquifer (LANL 2007, 095817). Dissolved concentrations of zinc ranged from 0.006 to 0.019 ppm in groundwater-screening samples collected at R-43 screen 1 during aquifer performance testing (Table B.2-2). Total dissolved concentrations of chromium ranged from 0.002 to 0.021 ppm (2 to 21 μg/L) at well R-43 screen 1 (Table B-2.4-1).

During aquifer performance testing of R-43 screen 2, dissolved concentrations of calcium and sodium ranged from 12.4 to 17.3 ppm and from 13.3 to 18.6 ppm, respectively (Table B-2.4-1). Dissolved concentrations of chloride and fluoride varied from 5.36 to 6.23 ppm and from 0.36 to 0.43 ppm, respectively, during testing of this screen (Table B-2.4-1). Dissolved concentrations of nitrate(N) and sulfate ranged from 0.76 to 4.88 ppm and from 5.89 to 13.2 ppm, respectively, in the R-43 screen 2 samples (Table B-2.4-1). Dissolved concentrations of chloride, nitrate(N), and sulfate at well R-43 screen 2 continued to exceed Laboratory background for the regional aquifer (LANL 2007, 095817). Concentrations of TOC ranged from 0.33 to 0.71 mgC/L at well R-43 screen 2 during aquifer performance testing (Table B-2.4-1).

During aquifer performance testing of R-43 screen 2, dissolved concentrations of iron and manganese ranged from 0.19 to 0.51 ppm and from 0.007 to 0.009 ppm, respectively (Table B-2.4-1). Dissolved concentrations of boron ranged from 0.031 to 0.056 ppm (Table B-2.4-1) at well R-43 screen 1, in which all but one of the samples are below the maximum background value of 51.6 μg/L for the regional aquifer (LANL 2007, 095817). Dissolved concentrations of zinc ranged from 0.003 to 0.010 ppm in groundwater-screening samples collected at R-43 screen 2 during aquifer performance testing (Table B-2.4-1). Total dissolved concentrations of chromium slightly varied from 0.002 to 0.003 ppm (2 to 3 μg/L) at well R-43 screen 2 (Table B-2.4-1).

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 number. This information is also included in text citations. ER ID numbers 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)

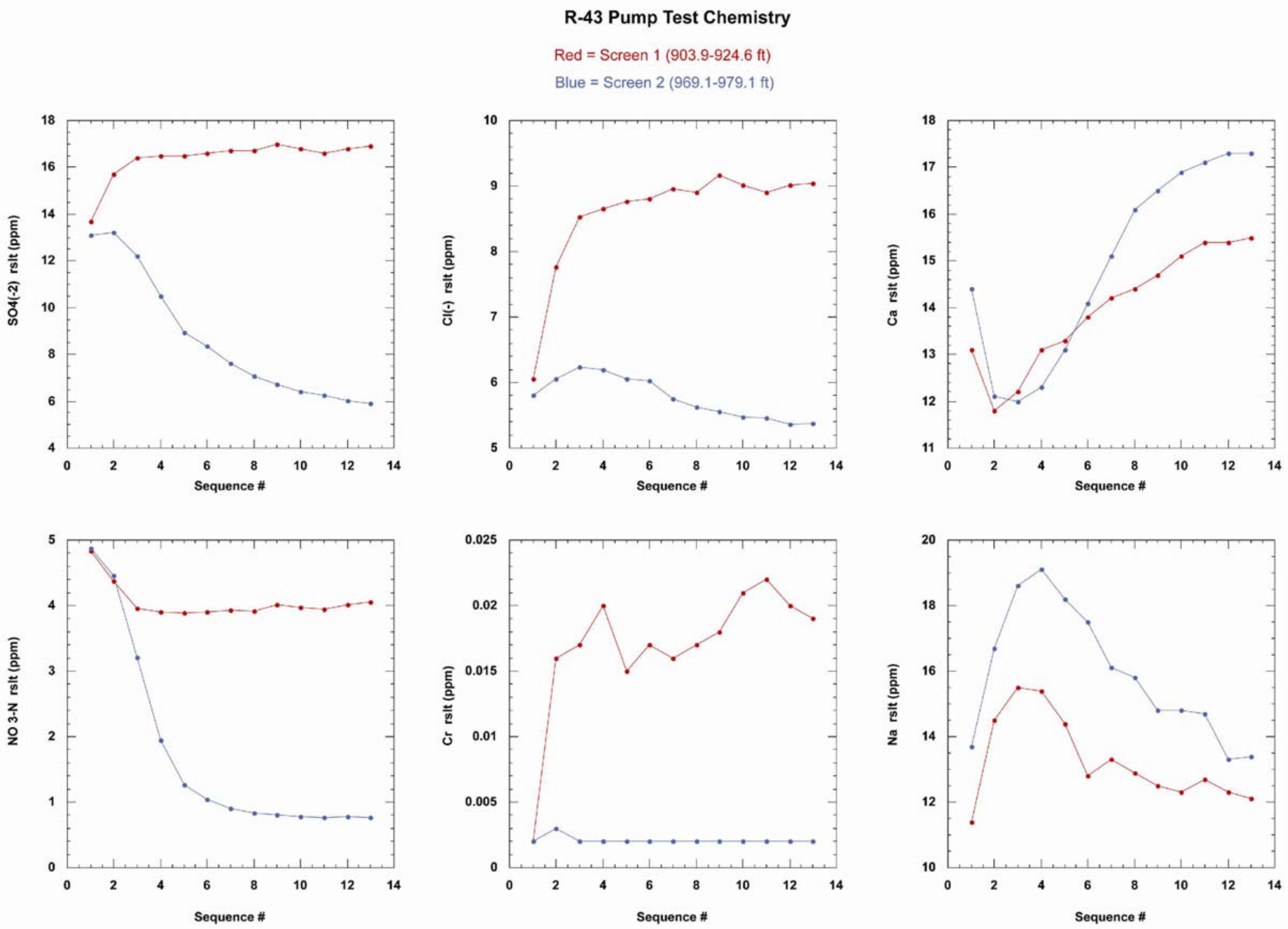


Figure B-2.5-1 Dissolved concentrations of calcium (Ca), chloride (Cl), total chromium (Cr), nitrate-N (NO_3-N), sodium (Na), and sulfate (SO_4) during aquifer performance testing of R-43

Table B-1.2-1
Well Development Volumes and Associated Field Water-Quality Parameters for Well SCI-2

Date	pH	Temp (°C)	DO (%)	ORP (mV)	Specific Conductivity (µS/cm)	Turbidity (NTU)	Purge Volume between Samples (gal.)	Cumulative Purge Volume (gal.)
SCI-2 Well Development								
8/13/08	7.50	20.75	6.08	188.0	558	2.6	10	10
	7.61	19.44	6.22	184.9	550	1.4	15	25
	7.66	19.31	5.90	186.5	547	-2.5	24	49
	7.66	19.21	6.33	186.9	546	-2.0	24	73
	7.67	19.30	6.11	186.4	546	-2.2	24	97
	7.67	18.66	6.24	191.9	546	-1.5	24	121
	7.63	18.76	6.41	192.1	544	-2.6	24	145
8/14/08	n/r*	n/r	n/r	n/r	n/r	n/r	12	157
	7.23	20.84	6.39	198.0	589	-0.7	12	169
	7.51	18.16	6.52	194.4	600	-0.5	12	181
	7.51	16.78	6.64	202.7	593	-1.1	12	193
	7.54	16.65	6.77	210.7	589	-1.9	12	205
9/7/08	n/r	n/r	n/r	n/r	n/r	n/r	7.5	212.5
9/29/08	n/r	n/r	n/r	n/r	n/r	n/r	308	520.5
9/30/08	n/r	n/r	n/r	n/r	n/r	n/r	490	1010.5
10/1/08	n/r	n/r	n/r	n/r	n/r	n/r	425	1435.5
10/2/08	7.40	21.52	7.61	200.4	583	1.9	7.5	1443
	7.55	20.38	8.06	210.0	587	1.3	7.5	1450.5
	7.54	19.50	8.12	212.3	586	1.8	7.5	1458
	7.55	18.46	8.21	210.1	584	1.4	7.5	1465.5
	7.55	17.27	8.40	200.4	585	1.3	7.5	1473
	7.54	16.64	8.17	196.0	582	1.9	7.5	1480.5
	7.56	17.41	8.21	202.4	523	2.0	7.5	1488
	7.55	17.50	8.46	216.1	583	1.2	7.5	1495.5
	7.54	17.42	8.62	203.0	584	7.8	7.5	1503
	7.56	17.82	8.55	215.3	580	2.4	7.5	1510.5
10/3/08	n/r	n/r	n/r	n/r	n/r	n/r	50	1560.5
10/6/08	n/r	n/r	n/r	n/r	n/r	n/r	89	1649.5
	7.53	16.7	8.65	194.6	586	3.5	9	1658.5
	7.54	15.6	8.75	199.0	587	2.4	9	1667.5
	7.57	14.7	8.71	195.1	584	2.5	9	1676.5
	7.57	14.1	9.23	202.6	583	0.6	9	1685.5
10/7/08	n/r	n/r	n/r	n/r	n/r	n/r	300	1985.5
10/8/08	n/r	n/r	n/r	n/r	n/r	n/r	400	2385.5
10/9/08	n/r	n/r	n/r	n/r	n/r	n/r	200	2585.5

*n/r = Not reported.

Note: Negative turbidity values may be caused by improper instrument calibration and/or instrument malfunction.

Table B.1-3-1
Analytical Results for Groundwater Screening Samples Collected from SCI-2, Sandia Canyon

Sample ID	Date Received	Sample Type	ER/RRES-WQH	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	TOC rslt (ppm)	Ca rslt (ppm)	stdev (Ca)
CASA-08-13655	8/3/2008	well, predevelopment	08-1601	0.001	U*	0.005	0.000	0.0008	0.0001	0.035	0.002	0.041	0.000	0.001	U	0.59	3.49	52.7	0.5
CASA-08-14155	8/14/2008	well development	08-1675	0.001	U	0.006	0.000	0.0010	0.0001	0.029	0.001	0.082	0.003	0.001	U	0.39	2.39	63.7	0.6
CASA-08-14156	8/14/2008	well development	08-1675	0.001	U	0.006	0.000	0.0009	0.0001	0.023	0.001	0.067	0.003	0.001	U	0.35	2.25	57.6	0.4
CASA-08-14157	8/14/2008	well development	08-1680	0.001	U	0.006	0.000	0.0009	0.0000	0.036	0.001	0.075	0.001	0.001	U	0.40	2.43	61.6	0.2
CASA-08-14158	10/6/2008	well development	09-33	0.001	U	0.001	U	0.0009	0.0000	0.029	0.000	0.078	0.001	0.001	U	0.30	1.68	62.6	0.2
CASA-08-14159	10/7/2008	well development	09-40	0.001	U	0.001	U	0.0008	0.0001	0.023	0.000	0.068	0.001	0.001	U	0.34	1.52	60.8	0.4
CASA-08-14160	10/14/2008	well development	09-70	0.001	U	0.001	U	0.0009	0.0000	0.037	0.000	0.058	0.001	0.001	U	0.33	1.49	59.0	0.2

* U = Not detected.

Table B.1-3-1 (continued)

Sample ID	Date Received	Sample Type	Cd rslt (ppm)	stdev (Cd)	Cl(-) ppm	ClO4(-) ppm	ClO4(-) (U)	Co rslt (ppm)	stdev (Co)	Alk-CO3 rslt (ppm)	ALK-CO3 (U)	C 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)
CASA-08-13655	8/3/2008	well, predevelopment	0.001	U*	47.4	0.005	U	0.001	U	0	U	0.503	0.001	0.001	U	0.002	0.000	0.23	0.01	U	91.2
CASA-08-14155	8/14/2008	well development	0.001	U	52.6	0.005	U	0.001	U	0	U	0.517	0.005	0.001	U	0.002	0.000	0.17	0.01	U	95.5
CASA-08-14156	8/14/2008	well development	0.001	U	47.4	0.005	U	0.001	U	0	U	0.497	0.002	0.001	U	0.002	0.000	0.18	0.01	U	93.9
CASA-08-14157	8/14/2008	well development	0.001	U	52.8	0.005	U	0.001	U	0	U	0.520	0.001	0.001	U	0.002	0.000	0.18	0.01	U	93.5
CASA-08-14158	10/6/2008	well development	0.001	U	58.1	0.005	U	0.001	U	0	U	0.689	0.003	0.001	U	0.001	0.000	0.18	0.01	U	98.9
CASA-08-14159	10/7/2008	well development	0.001	U	55.2	0.005	U	0.001	U	0	U	0.641	0.001	0.001	U	0.001	0.000	0.20	0.01	U	97.6
CASA-08-14160	10/14/2008	well development	0.001	U	52.0	0.005	U	0.001	U	0	U	0.642	0.001	0.001	U	0.001	0.000	0.20	0.01	U	95.6

Table B.1-3-1 (continued)

Sample ID	Date Received	Sample Type	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)	stdev (Na)	Ni rslt (ppm)	stdev (Ni)	NO2 (ppm)	NO2-N rslt	NO2-N (U)	NO3 ppm
CASA-08-13655	8/3/2008	well, predevelopment	0.00112	0.00002	2.75	0.03	0.023	0.000	12.4	0.1	0.069	0.001	0.006	0.000	18.4	0.1	0.017	0.000	0.01	0.003	U	19.5
CASA-08-14155	8/14/2008	well development	0.00224	0.00001	3.42	0.01	0.028	0.001	13.8	0.0	0.036	0.002	0.004	0.000	23.1	0.1	0.019	0.000	0.01	0.003	U	16.7
CASA-08-14156	8/14/2008	well development	0.00218	0.00001	3.11	0.00	0.028	0.001	13.5	0.1	0.020	0.001	0.004	0.000	22.6	0.1	0.017	0.001	0.01	0.003	U	16.3
CASA-08-14157	8/14/2008	well development	0.00229	0.00004	3.29	0.02	0.026	0.001	13.9	0.1	0.027	0.000	0.005	0.000	22.7	0.1	0.016	0.001	0.01	0.003	U	16.9
CASA-08-14158	10/6/2008	well development	0.00185	0.00002	3.36	0.00	0.025	0.000	13.7	0.1	0.017	0.000	0.002	0.000	21.9	0.0	0.017	0.000	0.01	0.003	U	18.7
CASA-08-14159	10/7/2008	well development	0.00128	0.00001	3.12	0.02	0.026	0.001	13.4	0.1	0.014	0.000	0.002	0.000	20.7	0.1	0.016	0.000	0.01	0.003	U	18.5
CASA-08-14160	10/14/2008	well development	0.00065	0.00002	2.99	0.01	0.025	0.001	13.2	0.0	0.010	0.000	0.001	0.000	20.2	0.1	0.016	0.000	0.01	0.003	U	19.4

Table B.1-3-1 (continued)

Sample ID	Date Received	Sample Type	NO3-N rslt	C2O4 rslt (ppm)	C2O4 (U)	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)
CASA-08-13655	8/3/2008	well, predevelopment	4.410	0.01	U	0.0002	U	7.48	0.01	0.005	0.000	0.001	u	0.003	0.000	28.4	0.2	60.9	0.5	0.001	U
CASA-08-14155	8/14/2008	well development	3.761	0.01	U	0.0002	U	7.54	0.02	0.006	0.000	0.001	U	0.002	0.000	30.6	0.2	65.5	0.4	0.001	U
CASA-08-14156	8/14/2008	well development	3.680	0.01	U	0.0002	U	7.57	0.03	0.005	0.000	0.001	U	0.003	0.000	30.7	0.2	65.8	0.5	0.001	U
CASA-08-14157	8/14/2008	well development	3.824	0.01	U	0.0002	U	7.32	0.03	0.006	0.000	0.001	U	0.003	0.000	30.2	0.3	64.6	0.6	0.001	U
CASA-08-14158	10/6/2008	well development	4.223	0.01	U	0.0002	U	7.62	0.04	0.005	0.000	0.001	U	0.003	0.000	29.7	0.2	63.6	0.4	0.001	U
CASA-08-14159	10/7/2008	well development	4.177	0.01	U	0.0002	U	7.53	0.05	0.004	0.000	0.001	U	0.003	0.000	28.9	0.3	61.9	0.7	0.001	U
CASA-08-14160	10/14/2008	well development	4.381	0.01	U	0.0002	U	7.59	0.04	0.005	0.000	0.001	U	0.003	0.000	30.0	0.2	64.2	0.5	0.001	U

Table B.1-3-1 (continued)

Sample ID	Date Received	Sample Type	SO4(-2) rslt (ppm)	Sr rslt (ppm)	stdev (Sr)	Th rslt (ppm)	stdev (Th)	Ti rslt (ppm)	stdev (Ti)	Tl rslt (ppm)	stdev (Tl)	U rslt (ppm)	stdev (U)	V rslt (ppm)	stdev (V)	Zn rslt (ppm)	stdev (Zn)	TDS (ppm)	Cations	Anions	Balance
CASA-08-13655	8/3/2008	well, predevelopment	72.9	0.230	0.001	0.001	U	0.002	U	0.001	U	0.0010	0.0000	0.001	U	0.043	0.002	379.9	4.5	4.7	-0.02
CASA-08-14155	8/14/2008	well development	84.9	0.285	0.003	0.001	U	0.002	U	0.001	U	0.0017	0.0000	0.001	U	0.004	0.000	420.8	5.4	5.1	0.03
CASA-08-14156	8/14/2008	well development	77.0	0.266	0.004	0.001	U	0.002	U	0.001	U	0.0016	0.0001	0.001	U	0.004	0.000	398.8	5.1	4.8	0.03
CASA-08-14157	8/14/2008	well development	86.8	0.279	0.001	0.001	U	0.002	U	0.001	U	0.0017	0.0001	0.001	U	0.005	0.000	417.7	5.3	5.1	0.02
CASA-08-14158	10/6/2008	well development	91.4	0.270	0.002	0.001	U	0.002	U	0.001	U	0.0014	0.0000	0.001	U	0.004	0.000	434.0	5.3	5.5	-0.02
CASA-08-14159	10/7/2008	well development	86.7	0.261	0.001	0.001	U	0.002	U	0.001	U	0.0013	0.0000	0.001	U	0.003	0.000	419.5	5.1	5.3	-0.01
CASA-08-14160	10/14/2008	well development	82.4	0.265	0.001	0.001	U	0.002	U	0.001	U	0.0012	0.0000	0.001	U	0.003	0.000	410.6	5.0	5.1	-0.01

* U = not detected.

Table B-2.2-1
Well Development Volumes, Aquifer Performance Testing Volumes, and Associated Field Water-Quality Parameters for Well R-43

Date	pH	Temp (°C)	DO (%)	ORP (mV)	Specific Conductivity (µS/cm)	Turbidity (NTU)	Purge Volume between Samples (gal.)	Cumulative Purge Volume (gal.)
R-43 Well Development								
10/22/08	n/r*	n/r	n/r	n/r	n/r	n/r	290	290
10/23/08	n/r	n/r	n/r	n/r	n/r	n/r	230	520
10/27/08 (both)	9.22	14.05	47.0	185.2	212	85.4	109	629
	9.07	17.05	41.0	163.6	193	14.1	84	713
	8.89	18.96	50.6	130.0	193	8.4	120	833
	8.79	20.88	56.2	125.5	192	6.9	138	971
	8.73	21.14	59.6	122.2	190	10.6	88	1059
	8.71	21.18	60.5	115.5	192	7.2	97	1156
	8.69	21.48	60.8	108.6	191	6.4	90	1246
	8.67	21.39	62.7	109.6	191	6.3	104	1350
	8.66	21.23	62.8	97.6	191	5.9	86	1436
10/27/08 (upper)	8.68	20.65	62.5	116.2	193	10.4	118	1554
	8.69	20.62	61.6	114.7	192	31.4	88	1642
	8.66	21.51	65.8	103.1	193	5.1	101	1743
	8.63	21.51	68.1	120.3	194	4.1	144	1887
	8.62	20.16	68.9	133.3	195	3.0	101	1988
	8.61	21.82	67.5	136.7	194	1.8	96	2084
	8.60	21.58	66.4	135.1	194	1.5	96	2180
	8.58	21.02	66.9	139.5	195	1.3	96	2276
	8.58	20.66	66.3	137.3	194	1.7	139	2415
	8.56	18.55	72.8	142.5	194	1.1	98	2513
	8.68	20.04	67.6	146.9	193	0.7	88	2601
	8.58	20.57	66.1	146.7	193	1.6	97	2698
	8.56	20.62	67.1	155.6	193	1.5	76	2774
	8.55	19.29	68.6	154.3	194	2.2	84	2858
10/29/08 (both)	8.37	17.61	73.8	142.1	175	40.8	76	2934
	8.42	19.03	67.7	129.6	175	17.5	99	3033
	8.47	19.55	61.9	121.7	179	11.0	87	3120
	8.46	20.83	59.3	119.9	179	9.0	87	3207
	8.47	20.94	61.5	113.6	183	5.9	94	3301
	8.47	21.08	64.0	109.2	185	6.3	94	3395

Table B-2.2-1 (continued)

Date	pH	Temp (°C)	DO (%)	ORP (mV)	Specific Conductivity (µS/cm)	Turbidity (NTU)	Purge Volume between Samples (gal.)	Cumulative Purge Volume (gal.)
10/29/08 (lower)	8.43	21.00	62.3	110.6	186	8.7	64	3459
	8.48	21.04	60.0	103.8	189	9.5	80	3539
	8.40	21.26	52.3	96.8	187	21.9	99	3638
	8.40	21.79	47.6	76.2	184	13.9	94	3732
	8.41	21.98	49.6	77.9	185	13.7	92	3824
	8.41	21.93	55.2	78.9	185	11.3	94	3918
	8.44	22.14	54.2	78.7	177	9.8	87	4005
	8.43	22.18	52.5	84.3	184	9.6	92	4097
	8.44	22.27	52.9	88.8	175	6.7	92	4189
	8.46	22.00	54.7	94.2	185	5.6	97	4286
	8.46	22.30	54.0	98.9	183	5.4	92	4378
	8.46	22.07	55.2	118.2	185	5.3	92	4470
	8.47	21.97	50.7	102.8	185	5.7	108	4578
	8.48	21.25	50.8	103.4	185	5.1	78	4656
	8.49	20.50	53.2	109.8	186	5.1	103	4759
	8.51	20.82	52.1	110.4	184	4.8	99	4858
	8.50	20.86	51.2	112.6	186	4.8	101	4959
	8.51	20.54	55.1	114.7	186	4.5	92	5051
	8.51	20.48	52.2	116.0	186	4.0	97	5148
	8.52	19.82	57.7	124.2	188	5.6	101	5249
	8.54	19.85	58.3	124.6	189	5.3	110	5359
10/30/08 (lower)	8.89	15.58	51.7	106.7	201	72.3	173	5532
	8.73	18.73	50.5	108.3	191	29.3	96	5628
	8.64	18.24	56.1	107.3	193	11.0	96	5724
	8.60	19.11	53.9	107.1	194	8.6	96	5820
	8.58	19.66	58.3	107.7	194	7.0	96	5916
	8.56	19.97	60.6	110.0	194	5.7	96	6012
	8.54	19.99	61.9	112.2	194	4.5	98	6110
	8.53	20.34	62.8	112.8	193	3.7	38	6148
	8.52	20.85	61.0	114.5	194	3.0	19	6167
	8.50	20.73	64.5	105.9	194	3.4	27	6194
10/30/08	n/r	n/r	n/r	n/r	n/r	13.1	483	6677

Date	pH	Temp (°C)	DO (%)	ORP (mV)	Specific Conductivity (µS/cm)	Turbidity (NTU)	Purge Volume between Samples (gal.)	Cumulative Purge Volume (gal.)
Aquifer Pump Test Volumes (upper screen)								
11/01/08	n/r	n/r	n/r	n/r	n/r	n/r	160	160
	n/r	n/r	n/r	n/r	n/r	n/r	222	382
	n/r	n/r	n/r	n/r	n/r	n/r	561	943
11/03/08	8.62	18.51	24.6	-4.4	174	9.1	200	1143
	8.48	21.37	61.9	40.0	186	-2.0	722	1865
	8.40	21.56	73.0	31.2	193	-2.8	851	2716
	8.38	21.39	76.1	29.1	192	-3.0	888	3604
	8.37	20.94	76.0	20.9	192	-3.1	852	4456
	8.37	20.83	75.2	12.9	192	-3.2	886	5342
	8.36	20.68	77.8	4.6	191	-3.1	922	6264
	8.35	20.66	78.5	0.1	191	-3.2	948	7212
	8.34	20.61	76.9	-3.5	190	-3.1	958	8170
11/04/08	8.34	20.58	75.0	-8.2	193	-3.3	941	9111
	8.33	20.54	75.9	-7.9	193	-3.5	962	10,073
	8.33	20.56	74.5	-9.9	193	-3.4	964	11,037
	8.32	20.99	78.8	-12.0	193	-3.6	964	12,001
Aquifer Pump Test Volumes (lower screen)								
11/06/08	n/r	n/r	n/r	n/r	n/r	n/r	264	264
	n/r	n/r	n/r	n/r	n/r	n/r	318	582
	n/r	n/r	n/r	n/r	n/r	n/r	425	1007
11/08/08	9.18	16.06	36.4	45.1	176	73.1	75	1082
	8.77	19.93	13.3	-109.0	191	12.3	202	1284
	8.52	21.35	53.8	17.0	187	0.1	828	2112
	8.44	21.40	67.6	26.3	192	n/r	1,068	3180
	8.40	21.36	82.2	55.0	193	-2.4	1,056	4236
	8.36	20.92	74.1	62.1	193	-1.8	1,068	5304
	8.33	20.83	90.6	46.3	196	-1.5	1,005	6309
	8.30	20.83	91.3	21.4	198	-2.7	1,052	7361
	8.28	20.78	88.9	2.4	200	-2.6	1,096	8457
	8.26	20.78	86.4	-6.6	201	-.04	1,058	9515
	8.24	20.75	85.7	-25.6	201	-3.0	1,060	10,575
	8.23	20.73	82.7	-32.2	202	-4.4	1,062	11,637
	8.23	20.71	81.2	-31.6	202	-2.7	1,056	12,693
	8.21	21.04	80.5	-34.2	202	-2.2	979	13,672

Date	pH	Temp (°C)	DO (%)	ORP (mV)	Specific Conductivity (µS/cm)	Turbidity (NTU)	Purge Volume between Samples (gal.)	Cumulative Purge Volume (gal.)
Aquifer Pump Test Volumes								
25,673 gal. (both screens)								
Postpump Test Purging (upper then lower screens)								
11/08/08	n/r	n/r	n/r	n/r	n/r	n/r	242	242
11/10/08	n/r	n/r	n/r	n/r	n/r	n/r	290	532

*n/r = Not reported.

Note: Negative oxidation reduction potential (ORP) and turbidity values may be caused by improper instrument calibration and/or instrument malfunction.

Table B.2-4-1
Analytical Results for Groundwater Screening Samples Collected from R-43, Sandia Canyon

Sample ID	Date Received	Sample Type	ER/RRES-WQH	Screen	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
CASA-08-14140	8/22/2008	borehole	08-1744	not applicable	not provided	0.001	U	0.006	0.000	0.0006	0.0001	0.023	0.000	0.032	0.001	0.001	U	0.20
CASA-08-14141	9/9/2008	borehole	08-1871	not applicable	894.5-895.0	0.001	U	0.311	0.004	0.0002	0.0000	0.026	0.000	0.014	0.000	0.001	U	0.03
CASA-08-14142	9/9/2008	borehole	08-1871	not applicable	914.5-915.0	0.001	U	0.204	0.002	0.0003	0.0000	0.040	0.000	0.012	0.000	0.001	U	0.08
CASA-08-14143	9/10/2008	borehole	08-1904	not applicable	954.5-955.0	0.001	U	0.065	0.001	0.0004	0.0000	0.032	0.000	0.032	0.000	0.001	U	0.08
CASA-08-14144	9/10/2008	borehole	08-1904	not applicable	974.5-975.0	0.001	U	0.091	0.000	0.0006	0.0000	0.033	0.000	0.045	0.000	0.001	U	0.06
CASA-08-14145	9/10/2008	borehole	08-1904	not applicable	992.5-993.0	0.001	U	0.106	0.001	0.0005	0.0001	0.030	0.000	0.050	0.001	0.001	U	0.06
CASA-08-14146	9/10/2008	borehole	08-1904	not applicable	1005.5-1006.0	0.001	U	0.062	0.002	0.0005	0.0002	0.030	0.001	0.055	0.002	0.001	U	0.07
CASA-08-14161	10/30/2008	well development	09-195	1	905-925	0.001	U	0.011	0.000	0.0015	0.0001	0.026	0.000	0.007	0.000	0.001	U	0.09
CASA-08-14162	10/30/2008	well development	09-195	1	905-925	0.001	U	0.011	0.000	0.0013	0.0000	0.024	0.000	0.008	0.000	0.001	U	0.09
CASA-08-14163	10/30/2008	well development	09-195	1	905-925	0.001	U	0.010	0.000	0.0014	0.0000	0.023	0.000	0.008	0.000	0.001	U	0.09
CASA-08-14164	10/30/2008	well development	09-195	1	905-925	0.001	U	0.010	0.000	0.0014	0.0000	0.024	0.000	0.009	0.000	0.001	U	0.89
CASA-08-14165	10/30/2008	well development	09-195	1	905-925	0.001	U	0.010	0.000	0.0011	0.0001	0.025	0.000	0.010	0.000	0.001	U	0.10
CASA-08-14166	10/30/2008	well development	09-195	2	970-980	0.001	U	0.010	0.000	0.0010	0.0000	0.023	0.000	0.009	0.000	0.001	U	0.09
CASA-08-14167	10/30/2008	well development	09-195	2	970-980	0.001	U	0.009	0.000	0.0009	0.0000	0.020	0.000	0.008	0.000	0.001	U	0.09
CASA-08-14168	10/30/2008	well development	09-195	2	970-980	0.001	U	0.009	0.000	0.0011	0.0001	0.056	0.001	0.008	0.000	0.001	U	0.09
CASA-08-14169	10/30/2008	well development	09-195	2	970-980	0.001	U	0.009	0.000	0.0014	0.0001	0.034	0.001	0.007	0.000	0.001	U	0.09
CASA-08-14170	10/30/2008	well development	09-195	2	970-980	0.001	U	0.008	0.000	0.0014	0.0000	0.027	0.000	0.008	0.000	0.001	U	0.09
CASA-08-14171	10/30/2008	well development	09-195	2	970-980	0.001	U	0.008	0.000	0.0014	0.0000	0.026	0.000	0.008	0.000	0.001	U	0.08
GW43-09-969	11/4/2008	pumping test	09-215	1	903.9-924.6	0.001	U	0.009	0.000	0.0009	0.0000	0.046	0.000	0.013	0.001	0.001	U	0.10
GW43-09-970	11/4/2008	pumping test	09-215	1	903.9-924.6	0.001	U	0.004	0.000	0.0012	0.0000	0.032	0.000	0.012	0.000	0.001	U	0.11
GW43-09-971	11/4/2008	pumping test	09-215	1	903.9-924.6	0.001	U	0.008	0.002	0.0016	0.0004	0.028	0.000	0.014	0.003	0.001	U	0.11
GW43-09-972	11/4/2008	pumping test	09-215	1	903.9-924.6	0.001	U	0.009	0.003	0.0017	0.0006	0.026	0.001	0.016	0.005	0.001	U	0.11
GW43-09-973	11/4/2008	pumping test	09-215	1	903.9-924.6	0.001	U	0.014	0.000	0.0013	0.0001	0.024	0.001	0.014	0.000	0.001	U	0.11
GW43-09-974	11/4/2008	pumping test	09-215	1	903.9-924.6	0.001	U	0.014	0.001	0.0012	0.0001	0.021	0.001	0.014	0.000	0.001	U	0.08
GW43-09-975	11/4/2008	pumping test	09-215	1	903.9-924.6	0.001	U	0.006	0.000	0.0012	0.0000	0.021	0.000	0.014	0.001	0.001	U	0.11
GW43-09-976	11/4/2008	pumping test	09-215	1	903.9-924.6	0.001	U	0.007	0.000	0.0013	0.0001	0.021	0.001	0.015	0.001	0.001	U	0.08
GW43-09-977	11/4/2008	pumping test	09-215	1	903.9-924.6	0.001	U	0.013	0.002	0.0013	0.0001	0.021	0.000	0.017	0.002	0.001	U	0.12
GW43-09-978	11/4/2008	pumping test	09-215	1	903.9-924.6	0.001	U	0.005	0.001	0.0013	0.0001	0.061	0.000	0.017	0.002	0.001	U	0.12
GW43-09-979	11/4/2008	pumping test	09-215	1	903.9-924.6	0.001	U	0.006	0.001	0.0013	0.0003	0.037	0.000	0.018	0.004	0.001	U	0.09
GW43-09-980	11/4/2008	pumping test	09-215	1	903.9-924.6	0.001	U	0.010	0.004	0.0013	0.0001	0.029	0.000	0.017	0.002	0.001	U	0.11
GW43-09-981	11/4/2008	pumping test	09-215	1	903.9-924.6	0.001	U	0.005	0.000	0.0012	0.0001	0.025	0.001	0.016	0.001	0.001	U	0.10
GW43-09-982	11/10/2008	pumping test	09-248	2	969.1-979.1	0.001	U	0.008	0.000	0.0011	0.0000	0.034	0.001	0.010	0.000	0.001	U	0.06
GW43-09-983	11/10/2008	pumping test	09-248	2	969.1-979.1	0.001	U	0.010	0.000	0.0015	0.0000	0.031	0.000	0.011	0.000	0.001	U	0.06
GW43-09-984	11/10/2008	pumping test	09-248	2	969.1-979.1	0.001	U	0.003	0.000	0.0015	0.0001	0.031	0.000	0.009	0.000	0.001	U	0.05
GW43-09-985	11/10/2008	pumping test	09-248	2	969.1-979.1	0.001	U	0.005	0.000	0.0014	0.0001	0.033	0.001	0.009	0.000	0.001	U	0.06
GW43-09-986	11/10/2008	pumping test	09-248	2	969.1-979.1	0.001	U	0.003	0.000	0.0013	0.0001	0.034	0.000	0.010	0.001	0.001	U	0.04
GW43-09-987	11/10/2008	pumping test	09-248	2	969.1-979.1	0.001	U	0.004	0.000	0.0013	0.0000	0.035	0.001	0.011	0.000	0.001	U	0.04
GW43-09-988	11/10/2008	pumping test	09-248	2	969.1-979.1	0.001	U	0.015	0.000	0.0013	0.0000	0.034	0.000	0.014	0.000	0.001	U	0.04
GW43-09-989	11/10/2008	pumping test	09-248	2	969.1-979.1	0.001	U	0.005	0.000	0.0012	0.0000	0.036	0.000	0.014	0.000	0.001	U	0.04
GW43-09-990	11/10/2008	pumping test	09-248	2	969.1-979.1	0.001	U	0.018	0.001	0.0013	0.0001	0.036	0.000	0.015	0.000	0.001	U	0.04
GW43-09-991	11/10/2008	pumping test	09-248	2	969.1-979.1	0.001	U	0.011	0.000	0.0012	0.0000	0.037	0.001	0.016	0.000	0.001	U	0.04
GW43-09-992	11/10/2008	pumping test	09-248	2	969.1-979.1	0.001	U	0.008	0.000	0.0012	0.0000	0.056	0.001	0.017	0.000	0.001	U	0.04
GW43-09-993	11/10/2008	pumping test	09-248	2	969.1-979.1	0.001	U	0.005	0.000	0.0012	0.0000	0.044	0.001	0.017	0.000	0.001	U	0.04
GW43-09-994	11/10/2008	pumping test	09-248	2	969.1-979.1	0.001	U	0.006	0.000	0.0012	0.0000	0.042	0.000	0.017	0.000	0.001	U	0.04

Table B.2-4-1 (continued)

Sample ID	Date Received	Sample Type	TOC rslt (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)	ALK-CO3 (U)	Cr rslt (ppm)	stdev (Cr)	Cs rslt (ppm)	stdev (Cs)
CASA-08-14140	8/22/2008	borehole	not measured	28.5	0.3	0.001	U	49.3	0.005	U	0.001	U	0	U	0.003	0.000	0.001	U
CASA-08-14141	9/9/2008	borehole	not measured	5.35	0.04	0.001	U	8.52	pending	pending	0.001	U	0	U	0.001	0.000	0.001	U
CASA-08-14142	9/9/2008	borehole	not measured	6.04	0.04	0.001	U	10.0	pending	pending	0.001	U	0	U	0.001	0.000	0.001	U
CASA-08-14143	9/10/2008	borehole	not measured	13.3	0.1	0.001	U	12.0	pending	pending	0.001	U	0	U	0.001	U	0.001	U
CASA-08-14144	9/10/2008	borehole	not measured	16.4	0.1	0.001	U	8.16	pending	pending	0.001	U	0	U	0.001	0.000	0.001	U
CASA-08-14145	9/10/2008	borehole	not measured	15.5	0.0	0.001	U	7.60	pending	pending	0.001	U	0	U	0.001	0.000	0.001	U
CASA-08-14146	9/10/2008	borehole	not measured	16.1	0.0	0.001	U	7.71	pending	pending	0.001	U	0	U	0.001	0.000	0.001	U
CASA-08-14161	10/30/2008	well development	1.07	13.3	0.0	0.001	U	7.76	pending	pending	0.001	U	8.31	0.5	0.006	0.000	0.001	U
CASA-08-14162	10/30/2008	well development	0.85	12.9	0.1	0.001	U	7.79	pending	pending	0.001	U	6.83	0.5	0.004	0.000	0.001	U
CASA-08-14163	10/30/2008	well development	0.74	12.4	0.1	0.001	U	8.25	pending	pending	0.001	U	0.8	U	0.006	0.000	0.001	U
CASA-08-14164	10/30/2008	well development	0.55	12.6	0.1	0.001	U	8.27	pending	pending	0.001	U	0.8	U	0.009	0.000	0.001	U
CASA-08-14165	10/30/2008	well development	0.63	12.8	0.1	0.001	U	8.67	pending	pending	0.001	U	0.8	U	0.008	0.001	0.001	U
CASA-08-14166	10/30/2008	well development	1.25	14.7	0.0	0.001	U	6.75	pending	pending	0.001	U	0.8	U	0.001	0.000	0.001	U
CASA-08-14167	10/30/2008	well development	1.76	15.1	0.1	0.001	U	7.06	pending	pending	0.001	U	0.8	U	0.001	0.000	0.001	U
CASA-08-14168	10/30/2008	well development	1.25	13.9	0.1	0.001	U	7.07	pending	pending	0.001	U	0.8	U	0.001	U	0.001	U
CASA-08-14169	10/30/2008	well development	1.41	13.0	0.1	0.001	U	7.20	pending	pending	0.001	U	0.8	U	0.001	0.000	0.001	U
CASA-08-14170	10/30/2008	well development	0.91	12.4	0.1	0.001	U	7.19	pending	pending	0.001	U	0.8	U	0.002	0.000	0.001	U
CASA-08-14171	10/30/2008	well development	0.60	12.0	0.1	0.001	U	7.83	pending	pending	0.001	U	0.8	U	0.001	0.000	0.001	U
GW43-09-969	11/4/2008	pumping test	0.88	13.1	0.1	0.001	U	6.05	pending	pending	0.002	0.000	0.8	U	0.002	0.000	0.001	U
GW43-09-970	11/4/2008	pumping test	0.84	11.8	0.1	0.001	U	7.77	pending	pending	0.001	U	0.8	U	0.011	0.000	0.001	U
GW43-09-971	11/4/2008	pumping test	0.86	12.2	0.1	0.001	U	8.53	pending	pending	0.001	U	0.8	U	0.017	0.004	0.001	U
GW43-09-972	11/4/2008	pumping test	0.91	13.1	0.0	0.001	U	8.65	pending	pending	0.002	0.000	0.8	U	0.020	0.008	0.001	U
GW43-09-973	11/4/2008	pumping test	0.93	13.3	0.1	0.001	U	8.77	pending	pending	0.003	0.000	0.8	U	0.015	0.001	0.001	U
GW43-09-974	11/4/2008	pumping test	0.92	13.8	0.1	0.001	U	8.81	pending	pending	0.002	0.000	0.8	U	0.017	0.001	0.001	U
GW43-09-975	11/4/2008	pumping test	0.85	14.2	0.0	0.001	U	8.96	pending	pending	0.002	0.000	0.8	U	0.016	0.001	0.001	U
GW43-09-976	11/4/2008	pumping test	0.75	14.4	0.1	0.001	U	8.90	pending	pending	0.001	U	0.8	U	0.017	0.002	0.001	U
GW43-09-977	11/4/2008	pumping test	0.82	14.7	0.2	0.001	U	9.17	pending	pending	0.001	U	0.8	U	0.018	0.001	0.001	U
GW43-09-978	11/4/2008	pumping test	0.87	15.1	0.1	0.001	U	9.02	pending	pending	0.001	U	0.8	U	0.021	0.004	0.001	U
GW43-09-979	11/4/2008	pumping test	0.75	15.4	0.1	0.001	U	8.90	pending	pending	0.001	U	0.8	U	0.022	0.007	0.001	U
GW43-09-980	11/4/2008	pumping test	0.84	15.4	0.1	0.001	U	9.01	pending	pending	0.001	U	0.8	U	0.020	0.002	0.001	U
GW43-09-981	11/4/2008	pumping test	0.95	15.5	0.1	0.001	U	9.04	pending	pending	0.001	U	0.8	U	0.019	0.002	0.001	U
GW43-09-982	11/10/2008	pumping test	0.71	14.4	0.1	0.001	U	5.81	pending	pending	0.001	U	7.42	0.5	0.002	0.000	0.001	U
GW43-09-983	11/10/2008	pumping test	0.57	12.1	0.0	0.001	U	6.05	pending	pending	0.001	U	5.46	0.5	0.003	0.000	0.001	U
GW43-09-984	11/10/2008	pumping test	0.57	12.0	0.1	0.001	U	6.23	pending	pending	0.001	U	6.95	0.5	0.002	0.000	0.001	U
GW43-09-985	11/10/2008	pumping test	0.48	12.3	0.0	0.001	U	6.20	pending	pending	0.001	U	6.05	0.5	0.002	0.000	0.001	U
GW43-09-986	11/10/2008	pumping test	0.33	13.1	0.1	0.001	U	6.05	pending	pending	0.001	U	5.15	0.5	0.002	0.000	0.001	U
GW43-09-987	11/10/2008	pumping test	0.39	14.1	0.0	0.001	U	6.03	pending	pending	0.001	U	6.41	0.5	0.002	0.000	0.001	U
GW43-09-988	11/10/2008	pumping test	0.60	15.1	0.0	0.001	U	5.75	pending	pending	0.001	U	0.8	U	0.002	0.000	0.001	U
GW43-09-989	11/10/2008	pumping test	0.47	16.1	0.0	0.001	U	5.62	pending	pending	0.001	U	0.8	U	0.002	0.000	0.001	U
GW43-09-990	11/10/2008	pumping test	0.41	16.5	0.1	0.001	U	5.56	pending	pending	0.001	U	0.8	U	0.002	0.000	0.001	U
GW43-09-991	11/10/2008	pumping test	0.41	16.9	0.1	0.001	U	5.47	pending	pending	0.001	U	0.8	U	0.002	0.000	0.001	U
GW43-09-992	11/10/2008	pumping test	0.43	17.1	0.0	0.001	U	5.46	pending	pending	0.001	U	0.8	U	0.002	0.000	0.001	U
GW43-09-993	11/10/2008	pumping test	0.42	17.3	0.1	0.001	U	5.36	pending	pending	0.001	U	0.8	U	0.002	0.000	0.001	U
GW43-09-994	11/10/2008	pumping test	0.41	17.3	0.1	0.001	U	5.38	pending	pending	0.001	U	0.8	U	0.002	0.000	0.001	U

Table B.2-4-1 (continued)

Sample ID	Date Received	Sample Type	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)
CASA-08-14140	8/22/2008	borehole	0.001	0.000	0.19	0.01	U	28.6	0.00005	U	4.75	0.01	0.040	0.001	7.92	0.02	0.453	0.001
CASA-08-14141	9/9/2008	borehole	0.002	0.000	0.78	0.25	0.00	113	0.00005	U	2.49	0.02	0.050	0.000	1.33	0.01	0.072	0.003
CASA-08-14142	9/9/2008	borehole	0.002	0.000	0.80	0.17	0.00	117	0.00008	0.00001	2.23	0.01	0.045	0.000	1.44	0.01	0.040	0.001
CASA-08-14143	9/10/2008	borehole	0.001	U	1.43	0.04	0.00	98.4	0.00011	0.00000	2.53	0.02	0.039	0.000	2.67	0.01	0.118	0.001
CASA-08-14144	9/10/2008	borehole	0.002	0.000	1.20	0.14	0.00	97.5	0.00030	0.00001	3.35	0.01	0.040	0.000	3.54	0.01	0.125	0.000
CASA-08-14145	9/10/2008	borehole	0.001	U	1.09	0.14	0.00	92.5	0.00018	0.00000	2.91	0.02	0.037	0.000	3.42	0.04	0.186	0.002
CASA-08-14146	9/10/2008	borehole	0.001	U	1.24	0.03	0.00	95.4	0.00015	0.00001	3.41	0.08	0.040	0.001	3.66	0.05	0.189	0.004
CASA-08-14161	10/30/2008	well development	0.001	U	0.45	0.32	0.00	63.5	0.00005	U	1.25	0.00	0.023	0.000	2.86	0.01	0.009	0.000
CASA-08-14162	10/30/2008	well development	0.001	U	0.69	0.52	0.00	60.9	0.00005	U	1.10	0.00	0.023	0.000	2.93	0.02	0.013	0.000
CASA-08-14163	10/30/2008	well development	0.001	0.000	0.68	0.65	0.00	69.7	0.00005	U	1.14	0.01	0.023	0.000	2.86	0.01	0.014	0.000
CASA-08-14164	10/30/2008	well development	0.002	0.000	0.63	0.90	0.00	70.0	0.00005	U	1.17	0.00	0.023	0.000	2.91	0.01	0.016	0.000
CASA-08-14165	10/30/2008	well development	0.001	0.000	0.44	1.14	0.00	70.1	0.00005	U	1.22	0.00	0.024	0.000	3.01	0.00	0.019	0.000
CASA-08-14166	10/30/2008	well development	0.003	0.000	0.52	0.52	0.00	58.6	0.00005	U	1.05	0.00	0.023	0.000	3.17	0.01	0.019	0.000
CASA-08-14167	10/30/2008	well development	0.001	U	0.46	0.25	0.00	63.7	0.00005	U	0.93	0.01	0.023	0.000	3.34	0.00	0.017	0.000
CASA-08-14168	10/30/2008	well development	0.001	U	0.68	0.21	0.00	62.2	0.00005	U	0.93	0.01	0.025	0.000	3.30	0.00	0.016	0.000
CASA-08-14169	10/30/2008	well development	0.001	U	0.72	0.40	0.00	62.6	0.00005	U	0.89	0.00	0.024	0.000	3.17	0.02	0.015	0.000
CASA-08-14170	10/30/2008	well development	0.001	U	0.72	0.67	0.00	63.7	0.00005	U	0.92	0.00	0.024	0.000	3.12	0.01	0.016	0.000
CASA-08-14171	10/30/2008	well development	0.001	U	0.67	0.99	0.00	70.3	0.00005	U	0.98	0.00	0.024	0.000	3.08	0.02	0.017	0.000
GW43-09-969	11/4/2008	pumping test	0.007	0.001	0.49	1.26	0.01	58.7	0.00005	U	1.20	0.01	0.024	0.000	3.39	0.03	0.024	0.000
GW43-09-970	11/4/2008	pumping test	0.001	U	0.47	0.66	0.00	61.8	0.00005	U	1.12	0.00	0.025	0.000	3.39	0.01	0.015	0.000
GW43-09-971	11/4/2008	pumping test	0.001	U	0.47	0.76	0.00	67.2	0.00005	U	1.17	0.01	0.025	0.000	3.45	0.02	0.017	0.000
GW43-09-972	11/4/2008	pumping test	0.002	0.001	0.47	0.80	0.00	68.3	0.00005	U	1.22	0.00	0.025	0.000	3.55	0.01	0.016	0.000
GW43-09-973	11/4/2008	pumping test	0.002	0.000	0.50	0.83	0.01	68.4	0.00005	U	1.17	0.01	0.024	0.000	3.52	0.03	0.016	0.000
GW43-09-974	11/4/2008	pumping test	0.007	0.001	0.47	0.77	0.00	68.9	0.00005	U	1.08	0.01	0.022	0.000	3.31	0.01	0.015	0.000
GW43-09-975	11/4/2008	pumping test	0.005	0.000	0.56	0.82	0.00	68.4	0.00005	U	1.16	0.01	0.024	0.000	3.64	0.02	0.015	0.000
GW43-09-976	11/4/2008	pumping test	0.001	U	0.47	0.80	0.00	68.0	0.00005	U	1.16	0.00	0.024	0.000	3.68	0.05	0.015	0.000
GW43-09-977	11/4/2008	pumping test	0.001	0.000	0.49	0.79	0.00	68.0	0.00005	U	1.17	0.01	0.024	0.000	3.71	0.01	0.015	0.000
GW43-09-978	11/4/2008	pumping test	0.001	U	0.48	0.78	0.01	67.2	0.00005	U	1.21	0.01	0.025	0.000	3.66	0.03	0.015	0.000
GW43-09-979	11/4/2008	pumping test	0.001	0.000	0.47	0.79	0.00	67.0	0.00005	U	1.34	0.01	0.026	0.000	3.98	0.02	0.015	0.000
GW43-09-980	11/4/2008	pumping test	0.002	0.000	0.47	0.80	0.00	67.0	0.00005	U	1.25	0.01	0.025	0.000	3.92	0.01	0.015	0.000
GW43-09-981	11/4/2008	pumping test	0.001	U	0.48	0.82	0.01	66.1	0.00005	U	1.23	0.01	0.025	0.000	3.93	0.06	0.015	0.000
GW43-09-982	11/10/2008	pumping test	0.001	U	0.38	0.19	0.00	59.6	0.00008	0.00005	1.09	0.00	0.022	0.000	3.34	0.00	0.007	0.000
GW43-09-983	11/10/2008	pumping test	0.001	0.000	0.40	0.36	0.00	60.4	0.00005	U	0.95	0.01	0.025	0.000	3.07	0.02	0.008	0.000
GW43-09-984	11/10/2008	pumping test	0.001	U	0.39	0.45	0.00	71.2	0.00005	U	0.99	0.00	0.025	0.000	3.04	0.01	0.008	0.000
GW43-09-985	11/10/2008	pumping test	0.001	0.000	0.43	0.51	0.00	84.7	0.00005	U	1.02	0.01	0.027	0.001	3.22	0.02	0.009	0.000
GW43-09-986	11/10/2008	pumping test	0.001	U	0.38	0.49	0.00	92.7	0.00005	U	1.03	0.00	0.026	0.001	3.39	0.01	0.008	0.000
GW43-09-987	11/10/2008	pumping test	0.001	U	0.43	0.50	0.00	95.6	0.00005	U	1.04	0.01	0.027	0.001	3.60	0.03	0.009	0.000
GW43-09-988	11/10/2008	pumping test	0.002	0.000	0.39	0.48	0.00	105	0.00005	U	1.03	0.01	0.029	0.001	3.76	0.03	0.009	0.000
GW43-09-989	11/10/2008	pumping test	0.001	U	0.39	0.48	0.00	109	0.00005	U	1.08	0.01	0.028	0.000	4.05	0.04	0.009	0.000
GW43-09-990	11/10/2008	pumping test	0.001	0.000	0.37	0.46	0.00	110	0.00005	U	1.06	0.01	0.029	0.000	4.08	0.02	0.009	0.000
GW43-09-991	11/10/2008	pumping test	0.001	U	0.38	0.47	0.00	111	0.00005	U	1.16	0.00	0.029	0.001	4.25	0.02	0.009	0.000
GW43-09-992	11/10/2008	pumping test	0.001	U	0.37	0.49	0.00	112	0.00005	U	1.16	0.01	0.029	0.000	4.41	0.03	0.009	0.000
GW43-09-993	11/10/2008	pumping test	0.001	U	0.36	0.44	0.00	112	0.00005	U	1.07	0.01	0.029	0.000	4.14	0.03	0.008	0.000
GW43-09-994	11/10/2008	pumping test	0.001	U	0.38	0.44	0.00	112	0.00005	U	1.13	0.00	0.029	0.001	4.28	0.02	0.008	0.000

Table B.2-4-1 (continued)

Sample ID	Date Received	Sample Type	Mo rslt (ppm)	stdev (Mo)	Na rslt (ppm)	stdev (Na)	Ni rslt (ppm)	stdev (Ni)	NO2(ppm)	NO2-N rslt	NO2-N (U)	NO3 ppm	NO3-N rslt	C2O4 rslt (ppm)	C2O4 (U)	Pb rslt (ppm)	stdev (Pb)	Lab pH	PO4(-3) rslt (ppm)	PO4(-3) (U)
CASA-08-14140	8/22/2008	borehole	0.007	0.000	46.1	0.1	0.010	0.000	0.01	0.003	U	20.7	4.67	0.01	U	0.0002	U	6.93		
CASA-08-14141	9/9/2008	borehole	0.172	0.002	37.6	0.2	0.001	U	1.191	0.362	0.036	2.70	0.61	0.32	0.03	0.0002	U	7.83	0.42	0.04
CASA-08-14142	9/9/2008	borehole	0.191	0.002	46.9	0.2	0.001	U	0.576	0.175	0.02	11.6	2.61	0.27	0.03	0.0002	U	7.98	0.01	U
CASA-08-14143	9/10/2008	borehole	0.292	0.002	22.4	0.1	0.001	U	0.010	0.003	U	8.28	1.87	0.28	0.03	0.0002	U	7.76	0.01	U
CASA-08-14144	9/10/2008	borehole	0.236	0.001	19.0	0.1	0.001	U	0.010	0.003	U	3.71	0.84	0.01	U	0.0002	U	7.80	0.01	U
CASA-08-14145	9/10/2008	borehole	0.168	0.008	16.8	0.2	0.001	U	0.011	0.003	U	2.47	0.56	0.61	0.06	0.0002	U	7.85	0.01	U
CASA-08-14146	9/10/2008	borehole	0.093	0.002	17.6	0.3	0.001	U	0.010	0.003	U	2.61	0.59	0.15	0.02	0.0002	U	8.01	0.01	U
CASA-08-14161	10/30/2008	well development	0.003	0.000	18.0	0.1	0.001	U	0.01	0.003	U	19.1	4.32	0.01	U	0.0002	U	8.48	0.01	U
CASA-08-14162	10/30/2008	well development	0.003	0.000	17.5	0.1	0.001	U	0.01	0.003	U	19.7	4.45	0.01	U	0.0002	U	8.32	0.01	U
CASA-08-14163	10/30/2008	well development	0.003	0.000	18.7	0.1	0.001	U	0.01	0.003	U	18.8	4.25	0.01	U	0.0002	U	8.29	0.02	0.01
CASA-08-14164	10/30/2008	well development	0.003	0.000	18.9	0.1	0.001	U	0.01	0.003	U	18.3	4.14	0.01	U	0.0002	U	8.20	0.13	0.01
CASA-08-14165	10/30/2008	well development	0.003	0.000	18.9	0.1	0.001	U	0.01	0.003	U	18.1	4.09	0.01	U	0.0002	U	8.14	0.02	0.01
CASA-08-14166	10/30/2008	well development	0.002	0.000	12.6	0.0	0.001	U	0.01	0.003	U	21.8	4.92	0.01	U	0.0002	U	7.95	0.01	U
CASA-08-14167	10/30/2008	well development	0.003	0.000	13.2	0.1	0.001	U	0.01	0.003	U	20.9	4.73	0.01	U	0.0002	U	7.91	0.01	U
CASA-08-14168	10/30/2008	well development	0.003	0.000	14.8	0.1	0.001	U	0.01	0.003	U	21.6	4.89	0.01	U	0.0002	U	8.06	0.01	U
CASA-08-14169	10/30/2008	well development	0.003	0.000	15.8	0.1	0.001	U	0.01	0.003	U	21.4	4.84	0.01	U	0.0002	U	8.08	0.01	U
CASA-08-14170	10/30/2008	well development	0.005	0.000	17.4	0.1	0.001	U	0.01	0.003	U	20.7	4.68	0.01	U	0.0002	U	8.08	0.01	U
CASA-08-14171	10/30/2008	well development	0.005	0.000	19.1	0.0	0.001	U	0.01	0.003	U	18.6	4.21	0.01	U	0.0002	U	8.06	0.01	U
GW43-09-969	11/4/2008	pumping test	0.001	0.000	11.4	0.1	0.001	U	0.01	0.003	U	21.4	4.84	0.01	U	0.0013	0.0001	8.25	0.01	U
GW43-09-970	11/4/2008	pumping test	0.002	0.000	14.5	0.1	0.001	U	0.01	0.003	U	19.4	4.38	0.01	U	0.0002	U	8.10	0.01	U
GW43-09-971	11/4/2008	pumping test	0.002	0.000	15.5	0.1	0.001	U	0.01	0.003	U	17.5	3.96	0.01	U	0.0002	U	8.00	0.01	U
GW43-09-972	11/4/2008	pumping test	0.002	0.000	15.4	0.1	0.001	U	0.01	0.003	U	17.3	3.91	0.01	U	0.0002	U	8.13	0.01	U
GW43-09-973	11/4/2008	pumping test	0.003	0.000	14.4	0.1	0.001	U	0.01	0.003	U	17.2	3.89	0.01	U	0.0002	U	8.08	0.01	U
GW43-09-974	11/4/2008	pumping test	0.003	0.000	12.8	0.1	0.001	U	0.01	0.003	U	17.3	3.90	0.01	U	0.0002	0.0000	8.14	0.01	U
GW43-09-975	11/4/2008	pumping test	0.002	0.000	13.3	0.1	0.001	U	0.01	0.003	U	17.4	3.93	0.01	U	0.0002	U	8.12	0.01	U
GW43-09-976	11/4/2008	pumping test	0.002	0.000	12.9	0.1	0.001	U	0.01	0.003	U	17.4	3.92	0.01	U	0.0002	U	8.12	0.01	U
GW43-09-977	11/4/2008	pumping test	0.002	0.000	12.5	0.1	0.001	U	0.01	0.003	U	17.8	4.01	0.01	U	0.0002	U	8.11	0.01	U
GW43-09-978	11/4/2008	pumping test	0.002	0.000	12.3	0.2	0.001	U	0.01	0.003	U	17.6	3.97	0.01	U	0.0002	U	8.13	0.01	U
GW43-09-979	11/4/2008	pumping test	0.002	0.000	12.7	0.1	0.001	U	0.01	0.003	U	17.5	3.95	0.01	U	0.0002	U	8.12	0.01	U
GW43-09-980	11/4/2008	pumping test	0.002	0.000	12.3	0.1	0.001	U	0.01	0.003	U	17.8	4.02	0.01	U	0.0002	U	8.14	0.01	U
GW43-09-981	11/4/2008	pumping test	0.002	0.000	12.1	0.1	0.001	U	0.01	0.003	U	18.0	4.05	0.01	U	0.0002	U	8.14	0.01	U
GW43-09-982	11/10/2008	pumping test	0.004	0.001	13.7	0.1	0.001	U	0.01	0.003	U	21.6	4.88	0.01	U	0.0002	U	8.52	0.01	U
GW43-09-983	11/10/2008	pumping test	0.003	0.000	16.7	0.1	0.001	U	0.01	0.003	U	19.7	4.46	0.01	U	0.0002	U	8.21	0.01	U
GW43-09-984	11/10/2008	pumping test	0.005	0.000	18.6	0.1	0.001	U	0.01	0.003	U	14.2	3.21	0.01	U	0.0002	U	8.16	0.01	0.01
GW43-09-985	11/10/2008	pumping test	0.005	0.000	19.1	0.1	0.001	U	0.01	0.003	U	8.60	1.94	0.01	U	0.0002	U	8.14	0.02	0.01
GW43-09-986	11/10/2008	pumping test	0.006	0.001	18.2	0.1	0.001	U	0.01	0.003	U	5.63	1.27	0.01	U	0.0002	U	8.12	0.01	U
GW43-09-987	11/10/2008	pumping test	0.005	0.000	17.5	0.1	0.001	U	0.01	0.003	U	4.60	1.04	0.01	U	0.0002	U	8.11	0.03	0.01
GW43-09-988	11/10/2008	pumping test	0.004	0.000	16.1	0.2	0.001	U	0.01	0.003	U	3.98	0.90	0.01	U	0.0059	0.0000	8.08	0.02	0.01
GW43-09-989	11/10/2008	pumping test	0.003	0.000	15.8	0.1	0.001	U	0.01	0.003	U	3.71	0.84	0.01	U	0.0002	U	8.04	0.02	0.01
GW43-09-990	11/10/2008	pumping test	0.003	0.000	14.8	0.0	0.001	U	0.01	0.003	U	3.59	0.81	0.01	U	0.0002	U	8.04	0.02	0.01
GW43-09-991	11/10/2008	pumping test	0.002	0.000	14.8	0.2	0.001	U	0.01	0.003	U	3.46	0.78	0.01	U	0.0002	U	8.04	0.01	U
GW43-09-992	11/10/2008	pumping test	0.003	0.000	14.7	0.1	0.001	U	0.01	0.003	U	3.38	0.76	0.01	U	0.0002	U	8.05	0.02	0.01
GW43-09-993	11/10/2008	pumping test	0.002	0.000	13.3	0.1	0.001	U	0.01	0.003	U	3.45	0.78	0.01	U	0.0002	U	8.03	0.02	0.01
GW43-09-994	11/10/2008	pumping test	0.002	0.000	13.4	0.1	0.001	U	0.01	0.003	U	3.38	0.76	0.01	U	0.0002	U	8.05	0.01	0.01

Table B.2-4-1 (continued)

Sample ID	Date Received	Sample Type	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)	stdev (Sr)	Th rslt (ppm)	stdev (Th)	Ti rslt (ppm)
CASA-08-14140	8/22/2008	borehole	0.012	0.000	0.001	U	0.002	0.000	2.83	0.01	6.0	0.0	0.001	U	58.1	0.132	0.002	0.001	U	0.002
CASA-08-14141	9/9/2008	borehole	0.005	0.000	0.001	U	0.001	U	15.2	0.1	32.6	0.2	0.001	U	16.1	0.037	0.001	0.001	U	0.008
CASA-08-14142	9/9/2008	borehole	0.004	0.000	0.001	U	0.001	0.000	12.0	0.1	25.8	0.1	0.001	U	21.2	0.041	0.001	0.001	U	0.007
CASA-08-14143	9/10/2008	borehole	0.005	0.000	0.001	U	0.001	U	13.6	0.1	29.0	0.2	0.001	U	21.8	0.073	0.000	0.001	U	0.006
CASA-08-14144	9/10/2008	borehole	0.006	0.000	0.001	U	0.001	U	15.9	0.0	34.1	0.1	0.001	U	15.9	0.085	0.002	0.001	U	0.009
CASA-08-14145	9/10/2008	borehole	0.008	0.001	0.001	U	0.001	U	14.8	0.1	31.7	0.2	0.001	U	13.3	0.056	0.001	0.001	U	0.011
CASA-08-14146	9/10/2008	borehole	0.009	0.002	0.001	U	0.001	U	14.4	0.3	30.7	0.6	0.001	U	13.4	0.059	0.001	0.001	U	0.003
CASA-08-14161	10/30/2008	well development	0.003	0.000	0.001	U	0.002	0.000	33.1	0.4	70.9	0.9	0.001	U	15.3	0.054	0.000	0.001	U	0.002
CASA-08-14162	10/30/2008	well development	0.002	0.000	0.001	U	0.002	0.000	34.1	0.2	72.9	0.4	0.001	U	15.2	0.052	0.000	0.001	U	0.002
CASA-08-14163	10/30/2008	well development	0.002	0.000	0.001	U	0.002	0.000	33.9	0.2	72.5	0.5	0.001	U	15.9	0.050	0.000	0.001	U	0.002
CASA-08-14164	10/30/2008	well development	0.002	0.000	0.001	U	0.002	0.000	34.6	0.2	74.0	0.4	0.001	U	15.8	0.051	0.000	0.001	U	0.002
CASA-08-14165	10/30/2008	well development	0.002	0.000	0.001	U	0.001	0.000	35.4	0.0	75.7	0.0	0.001	U	16.2	0.053	0.000	0.001	U	0.002
CASA-08-14166	10/30/2008	well development	0.002	0.000	0.001	U	0.002	0.000	34.3	0.2	73.5	0.4	0.001	U	14.3	0.054	0.000	0.001	U	0.002
CASA-08-14167	10/30/2008	well development	0.002	0.000	0.001	U	0.001	0.000	34.0	0.2	72.8	0.4	0.001	U	14.9	0.056	0.001	0.001	U	0.002
CASA-08-14168	10/30/2008	well development	0.001	0.000	0.001	U	0.002	0.000	33.5	0.2	71.7	0.5	0.001	U	15.0	0.055	0.000	0.001	U	0.002
CASA-08-14169	10/30/2008	well development	0.002	0.000	0.001	U	0.002	0.000	33.5	0.2	71.7	0.4	0.001	U	15.1	0.052	0.000	0.001	U	0.002
CASA-08-14170	10/30/2008	well development	0.002	0.000	0.001	U	0.002	0.000	34.1	0.3	73.0	0.6	0.001	U	15.6	0.051	0.000	0.001	U	0.002
CASA-08-14171	10/30/2008	well development	0.002	0.000	0.001	U	0.001	0.000	34.1	0.2	73.0	0.5	0.001	U	15.4	0.051	0.000	0.001	U	0.002
GW43-09-969	11/4/2008	pumping test	0.002	0.000	0.001	U	0.002	0.000	35.3	1.9	75.5	4.1	0.001	U	13.7	0.059	0.000	0.001	U	0.002
GW43-09-970	11/4/2008	pumping test	0.002	0.000	0.001	U	0.002	0.000	36.0	0.3	77.0	0.5	0.001	U	15.7	0.057	0.000	0.001	U	0.002
GW43-09-971	11/4/2008	pumping test	0.002	0.000	0.001	U	0.002	0.000	36.1	0.3	77.2	0.7	0.001	U	16.4	0.057	0.000	0.001	U	0.002
GW43-09-972	11/4/2008	pumping test	0.003	0.001	0.001	U	0.003	0.001	36.4	0.3	78.0	0.6	0.001	U	16.5	0.058	0.000	0.001	U	0.002
GW43-09-973	11/4/2008	pumping test	0.002	0.000	0.001	U	0.002	0.000	35.4	0.4	75.8	0.9	0.001	U	16.5	0.058	0.000	0.001	U	0.002
GW43-09-974	11/4/2008	pumping test	0.002	0.000	0.001	U	0.002	0.000	33.0	0.5	70.5	1.0	0.001	U	16.6	0.055	0.000	0.001	U	0.002
GW43-09-975	11/4/2008	pumping test	0.002	0.000	0.001	U	0.002	0.000	35.6	0.3	76.3	0.7	0.001	U	16.7	0.060	0.000	0.001	U	0.002
GW43-09-976	11/4/2008	pumping test	0.002	0.000	0.001	U	0.002	0.000	35.7	0.3	76.5	0.6	0.001	U	16.7	0.060	0.001	0.001	U	0.002
GW43-09-977	11/4/2008	pumping test	0.002	0.000	0.001	U	0.002	0.000	35.0	0.3	74.8	0.6	0.001	U	17.0	0.060	0.000	0.001	U	0.002
GW43-09-978	11/4/2008	pumping test	0.002	0.000	0.001	U	0.002	0.000	34.5	0.2	73.9	0.4	0.001	U	16.8	0.060	0.001	0.001	U	0.002
GW43-09-979	11/4/2008	pumping test	0.002	0.001	0.001	U	0.002	0.000	36.6	0.2	78.3	0.5	0.001	U	16.6	0.063	0.001	0.001	U	0.002
GW43-09-980	11/4/2008	pumping test	0.002	0.000	0.001	U	0.002	0.000	36.9	0.2	79.0	0.4	0.001	U	16.8	0.063	0.000	0.001	U	0.002
GW43-09-981	11/4/2008	pumping test	0.002	0.000	0.001	U	0.002	0.000	36.4	0.6	77.9	1.4	0.001	U	16.9	0.063	0.000	0.001	U	0.002
GW43-09-982	11/10/2008	pumping test	0.002	0.000	0.001	U	0.001	0.000	33.1	0.2	70.8	0.4	0.001	U	13.1	0.056	0.000	0.001	U	0.002
GW43-09-983	11/10/2008	pumping test	0.002	0.000	0.001	U	0.002	0.000	33.9	0.2	72.6	0.5	0.001	U	13.2	0.057	0.001	0.001	U	0.002
GW43-09-984	11/10/2008	pumping test	0.002	0.000	0.001	U	0.001	0.000	34.1	0.3	73.0	0.6	0.001	U	12.2	0.052	0.003	0.001	U	0.002
GW43-09-985	11/10/2008	pumping test	0.002	0.000	0.001	U	0.001	U	34.9	0.3	74.7	0.6	0.001	U	10.5	0.056	0.000	0.001	U	0.002
GW43-09-986	11/10/2008	pumping test	0.002	0.000	0.001	U	0.001	U	35.0	0.3	75.0	0.6	0.001	U	8.94	0.057	0.001	0.001	U	0.002
GW43-09-987	11/10/2008	pumping test	0.002	0.000	0.001	U	0.001	U	35.5	0.4	75.9	0.8	0.001	U	8.36	0.060	0.000	0.001	U	0.002
GW43-09-988	11/10/2008	pumping test	0.002	0.000	0.001	U	0.001	U	34.7	0.4	74.3	0.8	0.001	U	7.62	0.071	0.001	0.001	U	0.002
GW43-09-989	11/10/2008	pumping test	0.002	0.000	0.001	U	0.001	U	35.6	0.2	76.2	0.4	0.001	U	7.08	0.072	0.000	0.001	U	0.002
GW43-09-990	11/10/2008	pumping test	0.002	0.000	0.001	U	0.001	U	35.2	0.2	75.3	0.5	0.001	U	6.71	0.075	0.001	0.001	U	0.002
GW43-09-991	11/10/2008	pumping test	0.002	0.000	0.001	U	0.001	U	35.9	0.5	76.8	1.1	0.001	U	6.41	0.076	0.001	0.001	U	0.002
GW43-09-992	11/10/2008	pumping test	0.002	0.000	0.001	U	0.001	U	36.9	0.5	79.1	1.0	0.001	U	6.26	0.074	0.001	0.001	U	0.002
GW43-09-993	11/10/2008	pumping test	0.002	0.000	0.001	U	0.001	U	34.3	0.4	73.5	0.9	0.001	U	6.02	0.077	0.000	0.001	U	0.002
GW43-09-994	11/10/2008	pumping test	0.002	0.000	0.001	U	0.001	U	35.2	0.1	75.2	0.1	0.001	U	5.89	0.077	0.000	0.001	U	0.002

Table B.2-4-1 (continued)

Sample ID	Date Received	Sample Type	stdev (Ti)	Tl rslt (ppm)	stdev (Tl)	U rslt (ppm)	stdev (U)	V rslt (ppm)	stdev (V)	Zn rslt (ppm)	stdev (Zn)	TDS (ppm)	Cations	Anions	Balance
CASA-08-14140	8/22/2008	borehole	U	0.001	U	0.0002	U	0.001	U	0.002	0.000	252	4.2	3.4	0.11
CASA-08-14141	9/9/2008	borehole	0.000	0.001	U	0.0002	U	0.002	0.000	0.002	0.000	222	2.1	2.5	-0.10
CASA-08-14142	9/9/2008	borehole	0.000	0.001	U	0.0005	0.0000	0.002	0.000	0.001	0.000	244	2.5	2.9	-0.07
CASA-08-14143	9/10/2008	borehole	0.000	0.001	U	0.0007	0.0000	0.002	0.000	0.001	0.000	213	1.9	2.6	-0.15
CASA-08-14144	9/10/2008	borehole	0.000	0.001	U	0.0010	0.0000	0.003	0.000	0.001	0.000	204	2.0	2.3	-0.06
CASA-08-14145	9/10/2008	borehole	0.000	0.001	U	0.0009	0.0001	0.003	0.001	0.001	0.000	188	1.9	2.1	-0.06
CASA-08-14146	9/10/2008	borehole	0.000	0.001	U	0.0010	0.0002	0.003	0.001	0.001	0.000	192	2.0	2.2	-0.05
CASA-08-14161	10/30/2008	well development	U	0.001	U	0.0004	0.0000	0.007	0.000	0.001	U	221.2	1.7	2.2	-0.12
CASA-08-14162	10/30/2008	well development	U	0.001	U	0.0003	0.0000	0.007	0.000	0.003	0.002	219.3	1.7	2.1	-0.12
CASA-08-14163	10/30/2008	well development	U	0.001	U	0.0003	0.0000	0.007	0.000	0.001	U	222.8	1.7	2.1	-0.10
CASA-08-14164	10/30/2008	well development	U	0.001	U	0.0003	0.0000	0.008	0.000	0.021	0.002	225.4	1.7	2.1	-0.09
CASA-08-14165	10/30/2008	well development	U	0.001	U	0.0003	0.0000	0.006	0.000	0.004	0.002	227.3	1.7	2.1	-0.09
CASA-08-14166	10/30/2008	well development	U	0.001	U	0.0002	0.0000	0.006	0.000	0.009	0.001	208.4	1.6	1.9	-0.08
CASA-08-14167	10/30/2008	well development	U	0.001	U	0.0004	0.0000	0.005	0.000	0.004	0.001	213.7	1.6	1.9	-0.09
CASA-08-14168	10/30/2008	well development	U	0.001	U	0.0003	0.0000	0.006	0.000	0.005	0.000	212.5	1.6	1.9	-0.09
CASA-08-14169	10/30/2008	well development	U	0.001	U	0.0003	0.0000	0.007	0.000	0.007	0.001	213.2	1.6	2.0	-0.09
CASA-08-14170	10/30/2008	well development	U	0.001	U	0.0003	0.0000	0.007	0.000	0.008	0.001	216.5	1.7	2.0	-0.09
CASA-08-14171	10/30/2008	well development	U	0.001	U	0.0004	0.0000	0.006	0.000	0.012	0.002	223.2	1.7	2.1	-0.09
GW43-09-969	11/4/2008	pumping test	U	0.001	U	0.0002	0.0000	0.006	0.000	0.019	0.000	207.3	1.5	1.8	-0.11
GW43-09-970	11/4/2008	pumping test	U	0.001	U	0.0002	0.0000	0.007	0.000	0.006	0.000	214.8	1.5	1.9	-0.11
GW43-09-971	11/4/2008	pumping test	U	0.001	U	0.0003	0.0001	0.009	0.002	0.007	0.002	221.5	1.6	2.0	-0.12
GW43-09-972	11/4/2008	pumping test	U	0.001	U	0.0003	0.0001	0.011	0.005	0.009	0.005	224.4	1.7	2.0	-0.10
GW43-09-973	11/4/2008	pumping test	U	0.001	U	0.0003	0.0000	0.007	0.000	0.006	0.001	221.5	1.6	2.0	-0.12
GW43-09-974	11/4/2008	pumping test	U	0.001	U	0.0003	0.0000	0.007	0.000	0.007	0.000	215.5	1.6	2.1	-0.14
GW43-09-975	11/4/2008	pumping test	U	0.001	U	0.0003	0.0000	0.007	0.000	0.006	0.001	222.6	1.6	2.1	-0.12
GW43-09-976	11/4/2008	pumping test	U	0.001	U	0.0003	0.0000	0.007	0.001	0.007	0.001	221.9	1.6	2.0	-0.12
GW43-09-977	11/4/2008	pumping test	U	0.001	U	0.0003	0.0000	0.008	0.001	0.008	0.001	221.2	1.6	2.1	-0.12
GW43-09-978	11/4/2008	pumping test	U	0.001	U	0.0003	0.0000	0.009	0.002	0.007	0.001	219.2	1.6	2.0	-0.11
GW43-09-979	11/4/2008	pumping test	U	0.001	U	0.0003	0.0001	0.009	0.003	0.007	0.003	224.2	1.7	2.0	-0.09
GW43-09-980	11/4/2008	pumping test	U	0.001	U	0.0002	0.0000	0.008	0.001	0.006	0.001	224.8	1.7	2.0	-0.10
GW43-09-981	11/4/2008	pumping test	U	0.001	U	0.0002	0.0000	0.008	0.000			223.1	1.7	2.0	-0.10
GW43-09-982	11/10/2008	pumping test	U	0.001	U	0.0002	0.0000	0.005	0.000	0.003	0.000	211.7	1.6	2.0	-0.11
GW43-09-983	11/10/2008	pumping test	U	0.001	U	0.0003	0.0000	0.008	0.000	0.004	0.000	211.3	1.6	2.0	-0.10
GW43-09-984	11/10/2008	pumping test	U	0.001	U	0.0003	0.0000	0.008	0.000	0.006	0.000	219.5	1.7	2.1	-0.11
GW43-09-985	11/10/2008	pumping test	U	0.001	U	0.0004	0.0000	0.008	0.000	0.007	0.000	227.6	1.7	2.1	-0.10
GW43-09-986	11/10/2008	pumping test	U	0.001	U	0.0005	0.0000	0.008	0.000	0.006	0.000	230.3	1.8	2.2	-0.10
GW43-09-987	11/10/2008	pumping test	U	0.001	U	0.0005	0.0000	0.008	0.000	0.010	0.000	234.3	1.8	2.2	-0.11
GW43-09-988	11/10/2008	pumping test	U	0.001	U	0.0006	0.0000	0.009	0.000	0.010	0.000	235.1	1.8	2.2	-0.09
GW43-09-989	11/10/2008	pumping test	U	0.001	U	0.0006	0.0000	0.008	0.000	0.009	0.000	240.2	1.9	2.2	-0.08
GW43-09-990	11/10/2008	pumping test	U	0.001	U	0.0006	0.0000	0.008	0.000	0.010	0.000	239.4	1.8	2.2	-0.09
GW43-09-991	11/10/2008	pumping test	U	0.001	U	0.0006	0.0000	0.008	0.000	0.009	0.000	241.9	1.9	2.2	-0.08
GW43-09-992	11/10/2008	pumping test	U	0.001	U	0.0006	0.0000	0.008	0.000	0.010	0.000	245.3	1.9	2.2	-0.08
GW43-09-993	11/10/2008	pumping test	U	0.001	U	0.0007	0.0000	0.008	0.001	0.009	0.000	237.8	1.8	2.2	-0.10
GW43-09-994	11/10/2008	pumping test	U	0.001	U	0.0007	0.0000	0.008	0.000	0.009	0.000	240.3	1.8	2.2	-0.10

Note: Total organic carbon is not routinely analyzed in borehole water samples.
*U = not detected.

Appendix C

Aquifer Testing Report

C-1.0 INTRODUCTION

This appendix describes the hydraulic analysis of pumping tests at well R-43 located in Sandia Canyon near the upgradient edge of the existing chromium plume beneath the canyon. The tests were conducted in conjunction with testing of cross-gradient well R-42 located in Mortandad Canyon within the chromium plume. The primary objective of the analysis was to determine the hydraulic properties of the zones screened by R-43 screens 1 and 2, as well as the intervening aquitard between the two screen zones. A secondary objective was to look for cross-connection between R-43 and surrounding wells.

Testing consisted primarily of constant-rate pumping tests conducted on R-43 screens 1 and 2. During the tests on each screen, water levels were monitored in the nonpumped screen zone in R-43 to examine the properties of the intervening tight sediments and in R-42 to monitor cross-connection between the wells. In addition, water levels were monitored in adjacent intermediate well SCI-2 as well as regional wells R-11, R-13, R-15, R-28, and R-33 (screens 1 and 2).

Consistent with most of the R-well pumping tests conducted on the plateau, an inflatable packer system was used in R-43 to eliminate the effects of casing storage on the test data.

Conceptual Hydrogeology

R-43 is a dual screen well completed at the top of the Miocene riverine deposits, with 20.7 ft of screen between 903.9 and 924.6 ft below ground surface (bgs) (screen 1) and 10 ft of screen between 969.1 and 979.1 ft bgs (screen 2). The composite static water level (SWL) measured at the onset of testing was 893.35 ft bgs. When the zones were isolated with inflatable packers, the water level in zone 1 rose 0.35 ft to 893.00 ft bgs, while the level in zone 2 dropped 0.51 ft to 893.86 ft bgs. Thus, the level in screen 1 was 0.86 ft higher than that in screen 2, implying a downward gradient and somewhat resistive sediments between the two screen zones. A preliminary estimate of ground surface elevation at R-43 was 6730 ft above mean sea level (amsl), making the approximate SWL elevations in screens 1 and 2 5837 ft and 5836 ft, respectively.

Well R-42 is located about 900 ft southeast of R-43 and is completed at the top of the regional aquifer in Miocene pumiceous sediments, just above the riverine deposits. R-42 is a single-screen completion with 21.1 ft of screen between 931.8 and 952.9 ft bgs. The approximate water elevation in R-42 is 5839 ft.

R-43 Screen 1 Testing

R-43 screen 1 was tested from November 1 to November 5, 2008. Testing consisted of brief trial pumping on November 1, background data collection, and a 24-h constant-rate pumping test that was begun on November 3.

After brief pumping to fill the drop pipe and adjust the discharge rate, two trial tests were conducted on November 1. Trial 1 was conducted for 30 min from 2:30 p.m. until 3:00 p.m. and was followed by 60 min of recovery until 4:00 p.m. Trial 2 was conducted for 60 min from 4:00 p.m. until 5:00 p.m. The discharge rates were varied in both tests. Following shutdown, recovery/background was monitored for 2340 min until 8:00 a.m. on November 3.

At 8:00 a.m. on November 3, the 24-h pumping test was begun at a rate of 7.7 gpm. Pumping continued until 8:00 a.m. on November 4. Following shutdown, recovery measurements were recorded for 24 h until 8:00 a.m. on November 5.

R-43 Screen 2 Testing

R-43 screen 2 was tested from November 6 to November 10, 2008. Testing consisted of brief trial pumping on November 6, background data collection, and a 24-h constant-rate pumping test that was begun on November 8.

After brief pumping to fill the drop pipe and adjust the discharge rate, two trial tests were conducted on November 6. Trial 1 was conducted for 40 min from 12:00 p.m. to 12:40 p.m. and was followed by 50 min of recovery until 1:30 pm. Trial 2 was conducted for 60 min from 1:30 p.m. to 2:30 pm. Following shutdown, recovery/background was monitored for 2490 min until 8:00 a.m. on November 8.

At 8:00 a.m. on November 8, the 24-h pumping test was begun at a rate of 8.9 gpm. Pumping continued until 8:00 a.m. on November 9. Following shutdown, recovery measurements were recorded for 24 h until 8:00 a.m. on November 10.

Aerated Pumped Water

During testing, the water pumped from R-43 was significantly aerated, with large numbers of air bubbles visible in the water stream. The water from screen 1 was highly aerated, while that from screen 2 was moderately so. Because R-43 was drilled using compressed air, it is possible that substantial quantities of air were forced into the formation during the drilling operation and that some of the air may have dissolved in the groundwater. Pumping/depressurizing the well could have pulled in gaseous air and allowed dissolved air to come out of solution, resulting in the observed air bubbles in the discharge stream. Alternatively, it is possible that natural dissolved gas in the groundwater came out of solution and that was what was observed.

The presence of the air in the pumped water seemed to affect the pump operation by causing the discharge rates to vary throughout the pumping tests. Running aerated water through a submersible pump causes cavitation, reducing the pump efficiency in a chaotic way. This in turn causes the discharge rate to vary erratically. Thus, it was not possible to maintain constant rates during any of the tests. This placed a greater reliance than usual on the recovery data for assessing aquifer properties.

C-2.0 BACKGROUND DATA

The background water-level data collected while the pumping tests were run allowed the analyst to see what water-level fluctuations occur naturally in the aquifer and helped 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 between 90% and 100%. Barometric efficiency is defined as the ratio of water-level change divided by barometric pressure change, expressed as percentage. In the initial pumping tests conducted on the early R-wells, downhole pressure was monitored using a *vented* pressure transducer. This equipment measures the *difference* between the total pressure applied to the transducer and the barometric pressure, this difference being the true height of water above the transducer.

Subsequent pumping tests, including R-43, 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 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 Technical Area (TA-54) tower site from the Environmental Division Meteorology and Air Quality (ENV-MAQ). The TA-54 measurement location is at an elevation of 6548 ft amsl, whereas the wellhead elevation is approximately 6730 ft amsl. The SWLs of the two zones were about 893 ft below land surface, making the water-table elevation roughly 5837 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-43.

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

$$P_{WT} = P_{TA54} \exp\left[-\frac{g}{3.281R} \left(\frac{E_{R43} - E_{TA54}}{T_{TA54}} + \frac{E_{WT} - E_{R43}}{T_{WELL}} \right) \right] \qquad \textbf{Equation C-1}$$

Where, P_{WT} = barometric pressure at the water table inside R-43

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

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

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

E_{R43} = land surface elevation at R-43 site, in feet (6730 ft estimated)

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

E_{WT} = elevation of the water level in R-43, in ft (approximately 5837 ft)

T_{TA54} = air temperature near TA-54, in degrees Kelvin (assigned a value of 46.2 degrees Fahrenheit, or 281.0 degrees Kelvin, for the screen 1 test and 35.7 degrees Fahrenheit, or 275.0 degrees Kelvin, for the screen 2 test)

T_{WELL} = air temperature inside R-43, in degrees Kelvin (assigned a value of 65.9 degrees Fahrenheit, or 292.0 degrees Kelvin)

This formula is an adaptation of an equation provided by ENV-MAQ. 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 hydrographs to discern the correlation between the two.

C-3.0 IMPORTANCE OF EARLY DATA

When pumping or recovery first begins, the vertical extent of the cone of depression is limited to approximately the well screen length, the filter pack length or, the aquifer thickness in relatively thin permeable strata. For many pumping tests on the plateau, the early pumping period is the only time that the effective height of the cone of depression is known with certainty. 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, 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):

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

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

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 the R-43 pumping tests. Implementation of the packer was key in obtaining useful data from the R-43 pumping tests.

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:

$$s = \frac{114.6Q}{T} W(u) \qquad \textbf{Equation C-3}$$

Where,

$$W(u) = \int_u^\infty \frac{e^{-x}}{x} dx \qquad \textbf{Equation C-4}$$

and

$$u = \frac{1.87r^2 S}{Tt} \qquad \textbf{Equation C-5}$$

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 value: $W(u)$, $1/u$, s, and t. By using these match-point values, transmissivity and storage coefficient are computed as follows:

$$T = \frac{114.6Q}{s} W(u)$$ **Equation C-6**

$$S = \frac{Tut}{2693r^2}$$ **Equation C-7**

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)(1946), 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-8**

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

$$T = \frac{264Q}{\Delta s} \qquad \textbf{Equation C-9}$$

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

Q = discharge rate, in gallons per minute, and

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

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:

$$T = \frac{264Q}{\Delta s} \qquad \textbf{Equation C-10}$$

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. This was of paramount importance in the R-43 pumping tests because of the entrained air-induced discharge-rate fluctuations.

C-6.0 SPECIFIC CAPACITY METHOD

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

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

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

$$s_P = \frac{1-\frac{L}{b}}{\frac{L}{b}}\left[\ln\frac{b}{r_w} - 2.948 + 7.363\frac{L}{b} - 11.447\left(\frac{L}{b}\right)^2 + 4.675\left(\frac{L}{b}\right)^3\right]$$ **Equation C-11**

Where S_p = partial penetration correction, dimensionless

L = well screen length, in feet

b = aquifer thickness, in feet

r_w = radius of the pumping well, in feet

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-12**

Where K = hydraulic conductivity, in feet/day

Q = flow rate, in gallons per minute

T = transmissivity, in gallons per day per foot

T = time, in minutes

S_p = partial penetration correction, dimensionless

s = drawdown, in feet

b = aquifer thickness, in feet

r_w = radius of the pumping well, in feet

S = storage coefficient, dimensionless

To apply this procedure, a storage coefficient value must be assigned. Unconfined conditions were assumed for screen 1, while confined conditions were applied to screen 2. Storage coefficient values for confined conditions can be expected to range from about 10^{-5} to 10^{-3}, depending on aquifer thickness (1986, 104226), while those for unconfined conditions can be expected to range from about 0.01 to 0.25. 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. A confined value of 10^{-3} was used in the calculations for screen 2, while an assumed value of 0.1 was used for screen 1.

The analysis also requires assigning a value for the saturated aquifer thickness, b. For calculation purposes, the screen 1 zone was assumed to extend from the water table at 893 ft bgs to the midpoint of the blank pipe section between the two screens at 947 ft bgs. This resulted in an assigned aquifer thickness of 54 ft for screen 1. This was equivalent to assuming that the resistive zone between screens 1 and 2 was at the midpoint of the intervening blank section, even though the actual location of the aquitard was not known. However, the computed result is not particularly sensitive to the exact aquifer thickness because sediments far above or below the screen have little effect on yield and drawdown response. Therefore, the calculation based on the assumed aquifer thickness value was deemed to be adequate. For screen 2, an arbitrary thickness of 100 ft was assigned in the calculations.

Computing the lower-bound estimate of hydraulic conductivity can provide a useful frame of reference for evaluating the other pumping test calculations

C-7.0 BACKGROUND DATA ANALYSIS

Background aquifer pressure data collected during the R-43 tests were plotted along with barometric pressure to determine the barometric effect on water levels and to look for pumping response in the surrounding observation wells. The R-43 screens and R-42 were monitored using nonvented pressure transducers, while the remaining wells—SCI-2, R-11, R-13, R-15, R-28, and R-33—were monitored using vented transducers.

Figure C-7.0-1 shows aquifer pressure data from R-43 screen 1 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-43 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 screen 1 and screen 2 pumping tests are included on the figure for reference.

It is apparent that the swings in barometric pressure had little effect on the total aquifer pressure. A slight correlation between the hydrograph and barometric pressure can be seen at midday on November 2 when a substantial drop in barometric pressure coincided with a subtle, transient flattening of the hydrograph. The minor effect on the hydrograph implied that for a given change in barometric pressure there would have been an opposite and nearly equal change in the water level in the well had the well been open instead of packed off, such that the total pressure remained nearly unchanged. This implied a high barometric efficiency for screen 1.

Each continuous data segment showed aquifer pressure trending upward on the graph. This was likely recovery response from each of the pumping events applied to screen 1. At noon on November 7 there was an offset in the data trace followed by gradual recovery. This response corresponded to an episode of deflating the packer for 15 min and reinflating it. During deflation, water flowed from screen 1 to screen 2, because of the head difference between the two zones, resulting in drawdown at screen 1. After reinflating the packer, recovery occurred.

Finally, the hydrograph showed an effect at screen 1 from pumping screen 2. This is exhibited by the obvious change in the data trace that lasted from 8:00 a.m. on November 8 to 8:00 a.m. on November 9 during the 24-h pumping test on screen 2. The data segment during this time period is “noisier” than the rest of the graph because the screen 1 pressure transducer was located above the pump adjacent to the submersible pump cable. When the pump was operated, the electrical submersible pump cable introduced noise into the transducer signal. To remove some of the noise, an expanded scale graph of this segment of the hydrograph was plotted in Figure C-7.0-2 by using a rolling average of the aquifer pressure readings. On this graph the screen 1 response to pumping screen 2 is easier to see. The net drawdown in screen 1 appeared to be about 0.03 ft.

Figure C-7.0-3 shows the apparent hydrograph data from R-43 screen 2 along with the corrected barometric pressure data. The timing of the pumping periods for the screen 1 and screen 2 pumping tests are included on the figure for reference. Water levels were nearly steady early on for the first few days of observation, followed by decreasing levels thereafter. Los Alamos County supply well PM-4 had been operated nearly continuously for 24 h/d from late October to November 10, so it is likely that the decreasing water levels on the right side of the graph were a delayed response to groundwater withdrawal at PM-4.

The relationship between barometric pressure and water levels was not clarified by the available data. Two background monitoring data sets were available from screen 2: one from November 6 to 8 before testing screen 1 and another from November 6 to 8 as part of the screen 2 test. Figures C-7.0-4 and C-7.0-5, respectively, show expanded-scale plots of these two data sets.

The data in Figure C-7.0-4 show no correlation between the apparent hydrograph and barometric pressure plots, possibly implying a barometric efficiency of nearly 100%. According to this interpretation, the fluctuations in the apparent hydrograph, which are visible in Figure C-7.0-2 as minor “ripples,” could be caused by earth tides.

The data in Figure C-7.0-5, on the other hand, indicate a correlation with a barometric efficiency of 63%, based on the relative scales on the graph. It is not clear whether this apparent correlation is valid or just coincidental. Because no correlation was observed in Figure C-7.0-4, it seems likely that the apparent correlation from Figure C-7.0-5 was coincidental and that screen 2 has a barometric efficiency near 100%.

Finally, the hydrograph in Figure C-7.0-3 showed an effect at screen 2 from pumping screen 1. This is evidenced by the slight drawdown seen in the data trace that lasted from 8:00 a.m. on November 3 to 8:00 a.m. on November 4 during the 24-h pumping test on screen 1.

To clarify the drawdown effect, a rolling-average, expanded-scale plot of the response is shown in Figure C-7.0-6. According to the graph, the drawdown in screen 2 in response to pumping screen 1 was roughly 0.05 ft.

Figure C-7.0-7 shows the apparent hydrograph for R-42 recorded during the testing of R-43. The overall water-level trend was similar to that observed for R-43 screen 2, steady to slightly rising early on, followed by a steady decline. The latter trend was probably a response to the continuous operation of PM-4. The large swings in barometric pressure caused negligible change in total aquifer pressure, implying a near 100% barometric efficiency.

Water levels in R-42 showed no response to the R-43 pumping tests and other than the gradual decline in response to operation of PM-4, no apparent daily response to cycling other Los Alamos County wells.

Figure C-7.0-8 shows the hydrograph for SCI-2, the only intermediate well monitored during the R-43 pumping tests. SCI-2 is located roughly 100 ft from R-43. The data were collected using a vented pressure transducer, so the similarity between the hydrograph and barometric pressure data indicated a barometric efficiency of nearly 100%. The gradual rise of the hydrograph relative to the barometric pressure curve showed a general, steady increase in the intermediate water level during the period of observation. This could reflect seasonal, weather-related phenomena. It also is possible that it shows a recovery response from well drilling and construction activities during which water likely was produced from the intermediate zone. The monitoring record is not long enough to determine with certainty the cause of the observed water-level rise.

Figures C-7.0-9 through C-7.0-14 show comparisons of barometric pressure and hydrograph data from the remaining regional wells that were monitored using vented pressure transducers for R-11, R-13, R-15, R-28, R-33 screen 1, and R-33 screen 2, respectively. For all hydrographs, except for R-33 screen 2, the strong correlation between barometric pressure and water level was clear, showing near 100% barometric efficiencies. In each of these plots, there was a small, steady decline in water levels, presumably in response to continuous operation of PM-4. There was no evidence in any of these plots of a response to test pumping R-43.

The hydrograph for R-33 screen 2 showed large-amplitude fluctuations induced by operation of PM-5. The magnitude of these swings in water level precluded determination of barometric efficiency or possible response to pumping R-43 (unlikely based on the observation of lack of response in all other wells). Previous testing of R-33 in 2004 showed a low barometric efficiency for screen 2.

An interesting, though subtle, response was observed in the hydrograph for R-33 screen 1. These data have been plotted in Figure C-7.0-15 along with the operation times for the Los Alamos County production wells. A careful examination of the hydrograph suggested the possibility of reverse water-level fluctuations, also called the Noordbergum effect (Wolff 1970, 098242; Rodrigues 1983, 098239; Heish 1996, 098238), in response to pumping Los Alamos County well PM-5. This effect is occasionally seen in observation wells completed within aquitards or within aquifers adjacent to the pumped aquifer and separated from it by an aquitard.

Reverse water-level fluctuations are brought about by poroelastic effects and corresponding pore-pressure changes. When the main aquifer is pumped, it undergoes elastic deformation in response to the change in pore-water pressures, as well as the down thrust on the land surface at the wellhead associated with operating the pump. When the pumped aquifer becomes distorted, adjacent layers of aquitards and aquifers also are distorted. This creates transient pore-pressure changes within these units. At some locations, the pressures decline, while at other locations they rise (reverse water-level fluctuations). As time goes on, these pressure changes are relieved as water moves from high-pressure areas to low-pressure areas.

A detailed analysis of the data showed that when PM-5 began pumping, the water level in R-33 screen 1 rose by an amount that was disproportionate compared with the barometric pressure change at that time. Likewise, when PM-5 pumping stopped, there was a similar disproportionate drop in the R-33 screen 1 water level. As an example, according to the hydrograph, when PM-5 began pumping just before midnight on November 6, the water level rise in R-33 screen 1 exceeded the corresponding barometric pressure change. When pumping stopped, the dip in the R-33 screen 1 water level again exceeded the corresponding barometric pressure change. Figure C-7.0-16 shows an expanded-scale graph of these water-level fluctuations from November 7 that makes it easier to see the comparison of the changes in water level vis-à-vis barometric pressure.

As a second example, Figure C-7.0-17 shows an expanded view of similar data corresponding to the operation of PM-5 early on November 3. Again, there was a disproportionate rise in the screen 1 water level when pumping started and a disproportionate decline in level when pumping stopped. Observations consistent with this idea were noted for virtually every cycling event at PM-5 (note that it is difficult to discern this from Figure C-7.0-15 as it appears in this report because of the scale of the graph. The backup Excel spreadsheet is archived and available for detailed examination).

An alternative explanation for the observed response in screen 1 is the possibility that earth tides could have caused the fluctuations observed in the hydrograph. However, for this to be the case, the tide-induced “ripples” would have had to occur in just the right pattern (coinciding with operation of PM-5) to yield the observed results. Of these two options, it is more probable that reverse water-level fluctuations were responsible for the observed responses.

A third possibility is that the observed pressure perturbations could be related to the pump and packer system installed in R-33. For example, when operation of PM-5 lowers or raises the water level in screen 2 5 or 6 ft, it is possible that the changing pressure beneath the inflatable packer could cause it to move, expand, contract, deform, etc., giving rise to the small oscillations seen on the screen 1 hydrograph.

In summary, with the exception of R-33 screen 2, and possibly R-43 screen 2, there appeared to be a nearly 100% barometric efficiency response in each of the monitored wells and screen zones. During the R-43 screen 1 and 2 pumping tests, only the R-43 screen zones showed a drawdown response, with no detectable response observed in any of the other wells. The groundwater levels in intermediate well SCI-2 rose steadily during the monitoring period, while levels in most other wells declined, presumably in response to continuous operation of PM-4. Exceptions to this general observation were R-33 screen 2, in which large water-level fluctuations caused by PM-5 precluded observing this trend, and R-43 screen 1, which showed rising water levels, presumably recovery response to extensive pumping during the testing effort. R-33 screen 1 showed subtle water-level oscillations that could be related to earth tides or more likely possible reverse water-level fluctuations or elastic response of the sampling system components in response to operation of Los Alamos County well PM-5. Finally, pumping R-43 screen 1 caused roughly 0.05 ft of drawdown in screen 2, while pumping screen 2 drew down the level in screen 1 by about 0.03 ft.

C-8.0 R-43 SCREEN 1 DATA ANALYSIS

This section presents the data obtained from the R-43 screen 1 pumping tests and the results of the analytical interpretations. Data are presented for drawdown and recovery for trials 1 and 2 and the 24-h constant-rate pumping test.

Trial 1

Figure C-8.0-1 shows a semilog plot of the trial 1 drawdown data. The initial pumping rate was 6.7 gpm. The transmissivity value computed from the very early data (seconds) was 1570 gpd/ft. It was expected that this value represented the transmissivity of a sediment thickness approximately equal to the well screen length because the vertical growth of the cone of impression would have been minimal after such a short time. In other words, the earliest data reflect conditions immediately adjacent to the well screen. Based on a screen length of 20.7 ft, the computed hydraulic conductivity was 75.8 gpd/ft^2, or 10.4 ft/d. Use of the inflatable packers successfully eliminated casing-storage effects, allowing determination of the hydraulic conductivity of the near-well sediments.

Within a minute of starting the pump, the drawdown curve began flattening, typical of the response observed in most pumping tests on the plateau. In R-43 screen 1, this could have been caused by vertical expansion of the cone of depression (partial penetration), delayed yield associated with unconfined conditions for the shallow screened interval, leakage across the aquitard separating screens 1 and 2, or even discharge-rate variations or a lateral increase in aquifer transmissivity away from the well.

After 15 min of pumping, the discharge rate was increased to about 9.9 gpm, the maximum capacity of the pump. The drawdown reached a maximum at a pumping time of 20 min and then declined somewhat. A portion of the decline in drawdown was attributed to a gradual reduction in discharge rate associated with production of air along with the water. During testing, the water pumped from R-43 was significantly aerated, with large numbers of air bubbles visible in the water stream. Because R-43 was drilled using compressed air, it is likely that substantial quantities of air were forced into the formation during the drilling operation and that some of the air may have dissolved in the groundwater. Pumping/depressurizing the well could have pulled in gaseous air and allowed dissolved air to come out of solution, resulting in the observed air bubbles in the discharge stream. The presence of the air in the pumped water affected the pump operation by causing the discharge rates to vary throughout the pumping tests, including trial 1. Running aerated water through a submersible pump causes cavitation, reducing the pump efficiency in a chaotic way. This in turn causes the discharge rate to vary erratically.

It is also possible that the efficiency of the well may have increased slightly during the initial trial 1 test, contributing to the reduction in drawdown. During well development, the pumping rate was kept well below 10 gpm. Operating the pump at a greater rate during the trial 1 testing may have dislodged sediment around the well bore not previously removed during well development.

Figure C-8.0-2 shows a semilog plot of the trial 1 recovery data. The transmissivity value computed from the very early data was 1420 gpd/ft. Based on the screen length of 20.7 ft, the computed hydraulic conductivity was 68.6 gpd/ft^2 (or 9.2 ft/d) in good agreement with the time-drawdown value. In a short time, the curve flattened to the point that the ongoing change in water level was small in relation to background fluctuations.

Trial 2

Figure C-8.0-3 shows a semilog plot of the trial 2 drawdown data. The initial discharge rate was 10.3 gpm. The transmissivity value computed from the early data was 1550 gpd/ft, making the computed hydraulic conductivity 74.9 gpd/ft^2, or 10.0 ft/d.

The first several data points on Figure C-8.0-3 fell below the line of fit on the graph. The drop pipe used to hang the submersible pump had well worn threads and likely had one or more slightly leaky joints. This allowed some of the water in the drop pipe to drain between trial 1 and trial 2, creating a void at some point in the middle of the drop pipe string. When the pump was started for trial 2, it operated against reduced head initially until the void in the drop pipe was refilled. Pumping against reduced head resulted in a brief pumping rate burst greater than the subsequent rate, thus creating greater drawdown initially.

After the water level stabilized, the drawdown continued to vary somewhat up and down as a function of the variable discharge rate associated with pumping aerated water. After 28 min of pumping, the discharge rate was reduced. The new stabilized drawdown level continued to vary as well.

Figure C-8.0-4 shows a semilog plot of the trial 2 recovery data. The transmissivity value computed from the very early data was 1550 gpd/ft, making the computed hydraulic conductivity 74.9 gpd/ft^2, or 10.0 ft/d. The late-recovery data showed flattening associated with a combination of delayed yield, partial penetration, leakage, and perhaps other causes as described earlier.

C-8.1 R-43 Screen 1 24-h Constant-Rate Pumping Test

Figure C-8.1-1 shows a semilog plot of the drawdown data recorded during the 24-h constant-rate pumping test conducted at a discharge rate of 7.7 gpm. The early-time drawdown exceeded subsequent drawdown because of antecedent drainage of the drop pipe through leaky threaded joints, as described above. Subsequent data showed varying drawdown throughout the test corresponding to the erratic discharge rate associated with pumping aerated water. The variable discharge rates corresponding to antecedent drop pipe drainage and pumping aerated water precluded rigorous analysis of the drawdown data.

Figure C-8.1-2 shows a semilog plot of the recovery data following the 24-h test. The transmissivity value computed from the very early data was 1560 gpd/ft making the computed hydraulic conductivity

75.4 gpd/ft^2, or 10.1 ft/d. The late-recovery data showed flattening associated with the combination of delayed yield, partial penetration, leakage, and perhaps other effects as described earlier.

The flattening of the curve followed by an increase in slope at late recovery time lent support to the idea that delayed yield of the unconfined aquifer had occurred. The fact that the late-time slope remained very flat suggests leakage from the underlying aquifer sediments.

C-8.2 Specific Capacity Data

Specific capacity data were used along with well geometry to estimate a lower-bound conductivity value for the R-43 screen 1 zone for comparison to the pumping test values. In addition to specific capacity, other input values used in the calculations included the aquifer thickness of 54 ft (from the SWL to the midpoint of the blank pipe section between screens 1 and 2), a storage coefficient of 0.1, and a borehole radius of 0.51 ft. The calculations are somewhat insensitive to the assigned aquifer thickness, as long as the selected value is substantially greater than the screen length.

R-43 screen 1 produced 7.7 gpm with a drawdown of 4.58 ft after 24 h of pumping for a specific capacity of 1.68 gpm/ft. Applying the Brons and Marting method (1961, 098235) to these inputs yielded a lower-bound hydraulic conductivity value for the screened interval of 74.1 gpd/ft^2, or 9.9 ft/d. This was essentially identical to the values obtained from the time-drawdown and recovery analyses, lending credibility to the analyses and suggesting an efficient screen zone.

C-8.3 R-43 Screen 1 Summary

Table C-8.3-1 summarizes the hydraulic conductivity values obtained from the R-43 screen 1 pumping test analyses. The average hydraulic conductivity computed from the various tests was 9.9 ft/d.

The specific capacity obtained from screen 1 suggested a lower-bound hydraulic conductivity of 9.9 ft/d, consistent with the pumping test analyses and suggesting an efficient well.

C-9.0 R-43 SCREEN 2 DATA ANALYSIS

This section presents the data obtained from the R-43 screen 2 pumping tests and the results of the analytical interpretations. Data are presented for drawdown and recovery for trials 1 and 2 and the 24-h constant-rate pumping test.

Trial 1

Figure C-9.0-1 shows a semilog plot of the trial 1 drawdown data. The initial discharge rate was 9.4 gpm, adjusted later to 6.9 gpm. At either setting the rate varied because of the aerated water produced from screen 2, precluding rigorous analysis of the data.

Figure C-9.0-2 shows a semilog plot of the trial 1 recovery data. The transmissivity value computed from the early data was 830 gpd/ft. Based on the screen length of 10 ft, the computed hydraulic conductivity was 83.0 gpd/ft^2, or 11.1 ft/d.

The recovery curve flattened quickly after just several seconds. This was likely an artifact of vertical growth of the cone of depression (partial penetration). Contributing factors also could include leakage from the screen 1 aquifer and increasing transmissivity either laterally away from the well and/or at depth. The scatter in the data at late time precluded analysis of this portion of the graph.

Trial 2

Figure C-9.0-3 shows a graph of the trial 2 drawdown data from screen 2. The initial downward drawdown spike was attributed to antecedent drainage of a portion of the drop pipe as described previously. The subsequent data trace appeared “lumpy” in response to subtle discharge rate fluctuations associated with pumping aerated water. Over the last 30 min of pumping, the discharge rate increased from 7.0 to 7.2 gpm, presumably as the quantity of air in the discharge stream diminished.

Figure C-9.0-4 shows a semilog plot of the trial 2 recovery data. The transmissivity value computed from the very early data was 845 gpd/ft making the computed hydraulic conductivity 84.5 gpd/ft^2, or 11.3 ft/d. Note that the hydraulic conductivity calculation was based on just the first second or so of recovery response.

After a few seconds, the curve began flattening in response to partial penetration effects and perhaps other causes such as lateral transmissivity changes and leakage from the screen 1 zone and concomitant delayed yield associated with drawing down the overlying unconfined aquifer. Figure C-9.0-5 shows an expanded-scale plot of the middle and late recovery data. The line of fit shown on the graph resulted in a computed transmissivity of 30,300 gpd/ft.

At very late time, water levels actually reversed because background fluctuations exceeded water-level changes associated with recovery. The computed transmissivity value of 30,300 gpd/ft was based on a water-level change of only a tenth of a foot or so and thus could have been affected by subtle background fluctuations, as well as leakage and delayed yield from the overlying aquifer. Further, there was no way of knowing what sediment thickness corresponded to the computed transmissivity value, making it impossible to compute a corresponding hydraulic conductivity. Nevertheless, the data indicated a fairly large transmissivity of the sediments in the vicinity of and beneath R-43 screen 2.

C-9.1 R-43 Screen 2 24-h Constant-Rate Pumping Test

Figure C-9.1-1 shows drawdown recorded during the 24-h pumping test in R-43 screen 2. The plot shows a drawdown spike caused by antecedent drainage of a portion of the drop pipe as well as the usual erratic pumping water levels caused by discharge-rate variations associated with pumping aerated water. These effects precluded analysis of the drawdown graph.

Figure C-9.1-2 shows a semilog plot of the recovery data following pump shutoff. The first second or so of recovery supported a transmissivity calculation of 630 gpd/ft making the hydraulic conductivity of the screened interval 63 gpd/ft^2, or 8.4 ft/d.

After a few seconds, vertical expansion of the cone of depression resulted in a steady flattening of the recovery curve. Figure C-9.1-3 shows an expanded-scale view of the middle- and late-recovery data.

According to the figure, the intermediate data supported a transmissivity value of 29,500 gpd/ft. The validity of this value could be in doubt because of possible leakage and delayed yield effects from the screen 1 aquifer zone as well as background trends and fluctuations. The very-late data showed oscillations and reversal of water levels as the background fluctuations exceeded the ongoing head changes associated with recovery.

C-9.2 Specific Capacity Data

Specific capacity data were used along with well geometry to estimate a lower-bound conductivity value for the R-43 screen 2 zone for comparison to the pumping test values. In addition to specific capacity, other input values used in the calculations included an arbitrary assigned aquifer thickness of 100 ft, a storage coefficient of 0.001 and a borehole radius of 0.51 ft. The calculations are somewhat insensitive to the assigned aquifer thickness, as long as the selected value is substantially greater than the screen length.

R-43 screen 2 produced 8.9 gpm with a drawdown of 9.5 ft after 24 h of pumping for a specific capacity of 0.94 gpm/ft. Applying the Brons and Marting method to these inputs yielded a lower-bound hydraulic conductivity value for the screened interval of 74.3 gpd/ft^2, or 9.9 ft/d. This was similar to the values obtained from the recovery analyses, lending credibility to the analyses, and suggesting an efficient screen zone.

C-9.3 R-43 Screen 2 Summary

Table C-9.3-1 summarizes the hydraulic conductivity values obtained from the R-43 screen 2 pumping test analyses. The average hydraulic conductivity of the 10-foot screened zone computed from the various tests was 10.3 ft/d. The average bulk aquifer transmissivity computed from intermediate recovery data was 29,900 gpd/ft.

The specific capacity obtained from screen 2 suggested a lower-bound hydraulic conductivity of 9.9 ft/d, consistent with the pumping test analyses and suggesting an efficient well.

C-10.0 AQUITARD LEAKANCE/RESISTANCE

Data from the pumping tests were used to estimate the leakance of the tight sediments separating R-43 screen 1 from screen 2. Each of the 24-h tests supported estimation of this parameter.

Pumping R-43 screen 1 at 7.7 gpm produced approximately 0.05 ft of drawdown in screen 2, while pumping screen 2 at 8.9 gpm resulted in about 0.03 ft of drawdown in screen 1. These responses to pumping were simulated in a computer model of the two-aquifer system with an intervening aquitard. For each pumping test, the vertical hydraulic conductivity of the aquitard was adjusted until the observed drawdown in the nonpumped zone matched the field observation.

The modeling was performed using MODLFOW implemented under Schlumberger’s Visual MODFLOW. A brief summary of the model configuration and input parameters is as follows:

- area covered: 20,000 ft × 20,000 ft
- 116 rows × 116 columns × 13 layers
- upper screen length: 21 ft
- lower screen length: 10 ft
- transmissivity of upper aquifer: 4000 gpd/ft
- transmissivity of lower aquifer: 30,000 gpd/ft
- storage coefficient of upper aquifer: 0.05
- storage coefficient of pumped aquifer: 0.001
- vertical anisotropy ratio of aquifers: 10:1

Simulating the screen 1 pumping test yielded an aquitard leakance of 0.0089 inverse days (resistance of 112 d), which is a moderate value. Simulating the screen 2 pumping test yielded an aquitard leakance of 0.0033 inverse days (resistance of 303 d). Taking the geometric average of these values resulted in an estimated aqutard leakance of 0.0054 inverse-day and a resistance of 184 d.

These results implied a fairly conductive separating layer between screen 1 and screen 2 compared with what has been observed at other locations on the plateau where the head separation between the uppermost screens in multiscreened wells is greater than observed here. As a comparison, similar analysis at R-35a and R-35b yielded hydraulic resistance an order of magnitude greater than computed for R-43, while analysis of R-10 screens 1 and 2 data showed resistance more than 2 orders of magnitude greater. Note that part of the greater resistance at the other locations is attributable to the greater distance between the well screens. R-43 screens 1 and 2 are 44.5 ft apart, whereas the separation distance at R-35a/b is about 167 ft (accounting for elevation difference between the two wells) and the separation distance at R-10 is about 144 ft. Although computations like this have not been made for R-33, it is likely that the hydraulic resistance between screens 1 and 2 at that location is similar to what was determined for R-10, based on the large head difference between the screens in R-33. Thus, compared with other locations on the plateau, the potential for vertical groundwater movement at R-43 is relatively favorable.

C-11.0 SUMMARY

Constant-rate pumping tests were conducted on R-43 screens 1 and 2 in Sandia Canyon. The tests were conducted to gain an understanding of the hydraulic characteristics of the aquifers in which the screens were installed as well as the intervening aquitard between the screens. Additionally, several surrounding wells were monitored to check for hydraulic cross-connection to R-43. Numerous observations and conclusions were drawn for the tests as summarized below.

- The SWLin R-43 screen 1 was 0.86 ft higher than that in screen 2, suggesting the presence of intervening resistive sediments.
- Pumping either screen 1 or screen 2 produced a response in the nonpumped zone. No other drawdown response was observed in any of the other monitored wells; intermediate well SCI-2; and regional wells R-11, R-13, R-15, R-28, R-33 screens 1 and 2, and R-42.
- Most of the monitored wells showed barometric efficiencies of near 100%. Exceptions were R-43 screen 2, which yielded contradictory results and R-33 screen 2, in which large water-level fluctuations caused by pumping PM-5 precluded analysis (note a low barometric efficiency for this zone was determined from the original pumping test on R-33 in 2004).
- Water levels in intermediate well SCI-2 showed a steady rise, while levels in all other monitored zones showed a decline, likely induced by continuous operation of PM-4. Of note was that the R-42 hydrograph showed a slight rise for the first few days of monitoring, indicating a delayed response to operation of PM-4. This was contrary to the response of other R-wells located similar distances from PM-4. This may suggest that the sediments screened in R-42 are more poorly hydraulically connected to the deep aquifer than those penetrated by other R-wells.
- Background data from R-33 screen 1 indicated reverse water-level fluctuations in response to the operation of PM-5. This could be a manifestation of the Noordbergum effect or simply be an elastic deformation of the sampling system components installed in R-33 in response to 5 or 6 ft of drawdown/recovery in screen 2.
- The drawdown observed in the nonpumped screen zone for each of the pumping tests supported determination of an average aquitard leakance of 0.0054 inverse-day, which is 1 to 2 orders of magnitude greater than observed and surmised at other locations, such as R-10, R-33, and R-35a/b.

- Aerated water was produced from both screens during testing. It is possible gas came out of solution during the test or that this was air introduced into the formation during the original drilling operation, which utilized compressed air drilling methods. The air in the water stream caused pump cavitation, resulting in erratic pumping rates that could not be kept constant. This limited the use of drawdown data but did not preclude conventional analysis of recovery data.
- The use of inflatable packers successfully eliminated casing-storage effects, essential in determining aquifer properties.
- Pumping tests on both screen zones were dominated by the effects of partial penetration (vertical growth of the cone of depression), delayed yield of the upper unconfined aquifer, and leakage between the two screen zones across the somewhat conductive intervening sediments. The upper zone tests showed effects within 1 min of pumping, while the lower zone showed effects within a second or so of pumping. This highlighted the reliance on early data for determining aquifer coefficients.
- Leaky threaded joints in the drop pipe used to hang the submersible test pump allowed drainage of a portion of the pipe between pumping events. Pumping against reduced head briefly until the void in the drop pipe was refilled resulted in chaotic discharge rate changes at the onset of pumping, corrupting much of the early drawdown data and rendering it unusable for determining aquifer properties.
- The hydraulic conductivity of the sediments adjacent to screen 1 was determined to be 9.9 ft/d. Specific capacity data yielded a lower-bound hydraulic conductivity for this screened interval of 9.9 ft/d, consistent with the pumping test results and indicating a good well efficiency.
- The hydraulic conductivity of the sediments adjacent to screen 2 was determined to be 10.3 ft/d. Specific capacity data yielded a lower-bound hydraulic conductivity for this screened interval of 9.9 ft/d, consistent with the pumping test results and indicating a good well efficiency.
- Intermediate data from screen 2 yielded a computed transmissivity value of approximately 30,000 gpd/ft. Though the calculation could have been influenced by leakage and/or delayed yield from the upper zone and background water-level fluctuations, the results nevertheless suggested a high transmissivity for the screen 2 sediments. There was no way to determine the vertical thickness of sediments represented by this transmissivity value.

C-12.0 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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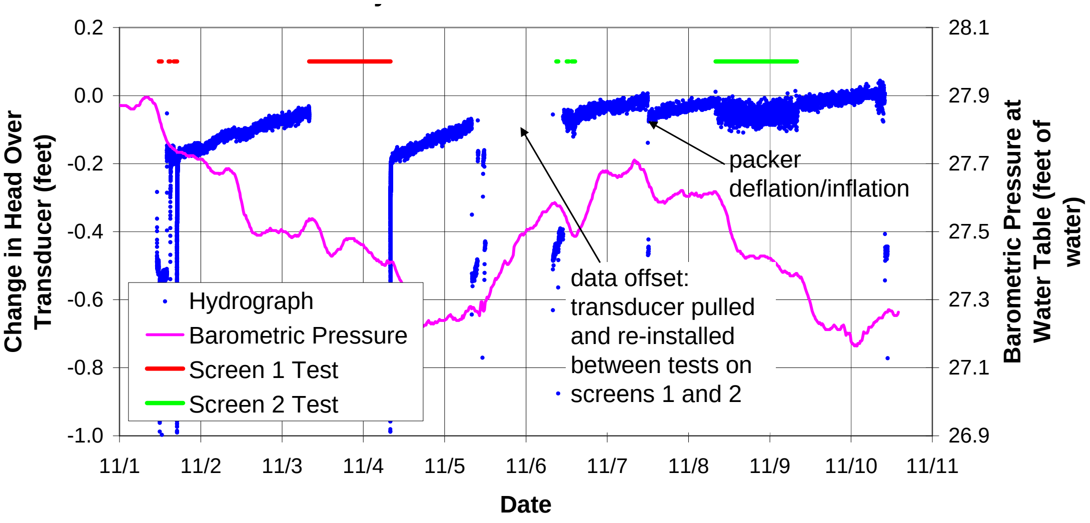

Figure C-7.0-1 Comparison of R-43 screen 1 apparent hydrograph and adjusted TA-54 barometric pressure

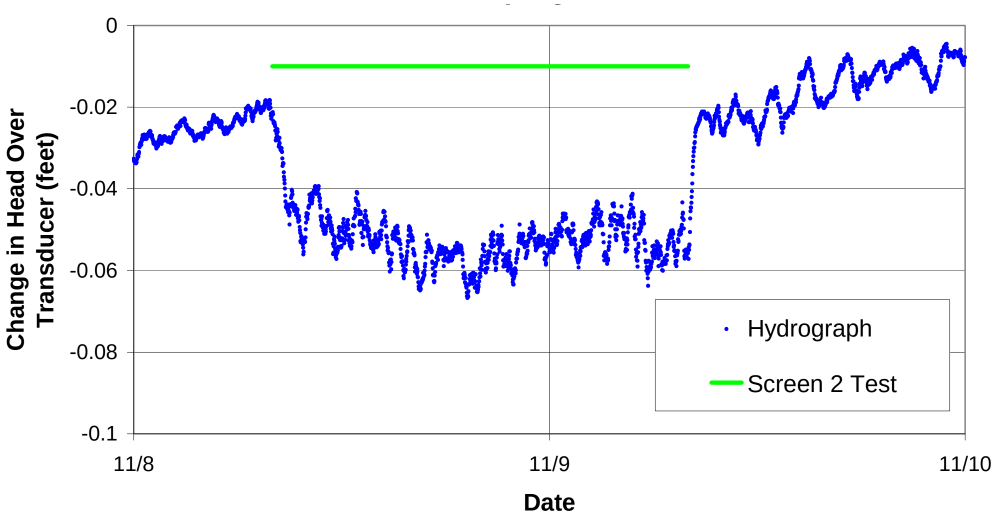

Figure C-7.0-2 R-43 screen 1 rolling average response to pumping screen 2

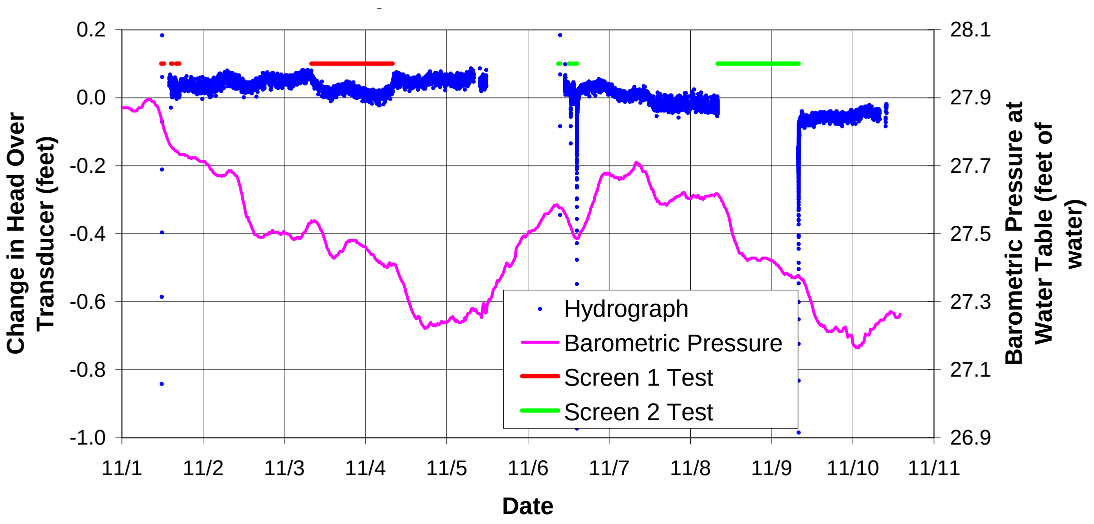

Figure C-7.0-3 Comparison of R-43 screen 2 apparent hydrograph and adjusted TA-54 barometric pressure

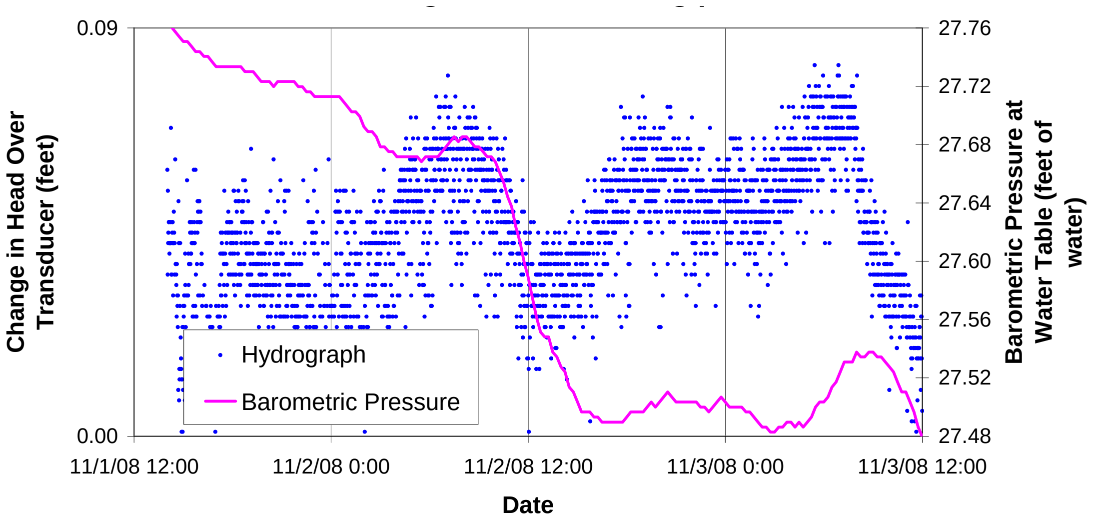

Figure C-7.0-4 Screen 2 apparent hydrograph during screen 1 background monitoring period

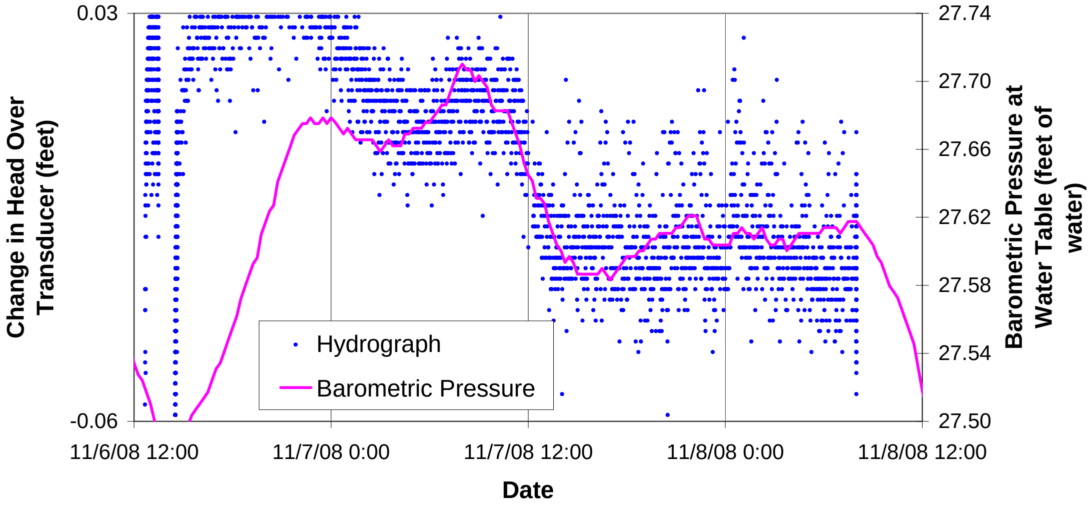

Figure C-7.0-5 Screen 2 apparent hydrograph during screen 2 background monitoring period

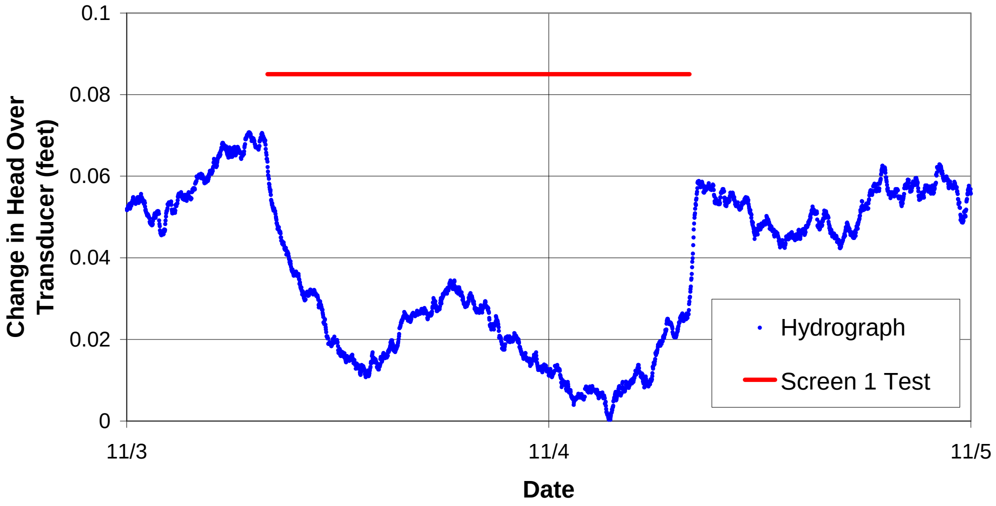

Figure C-7.0-6 R-43 screen 2 rolling average response to pumping screen 1

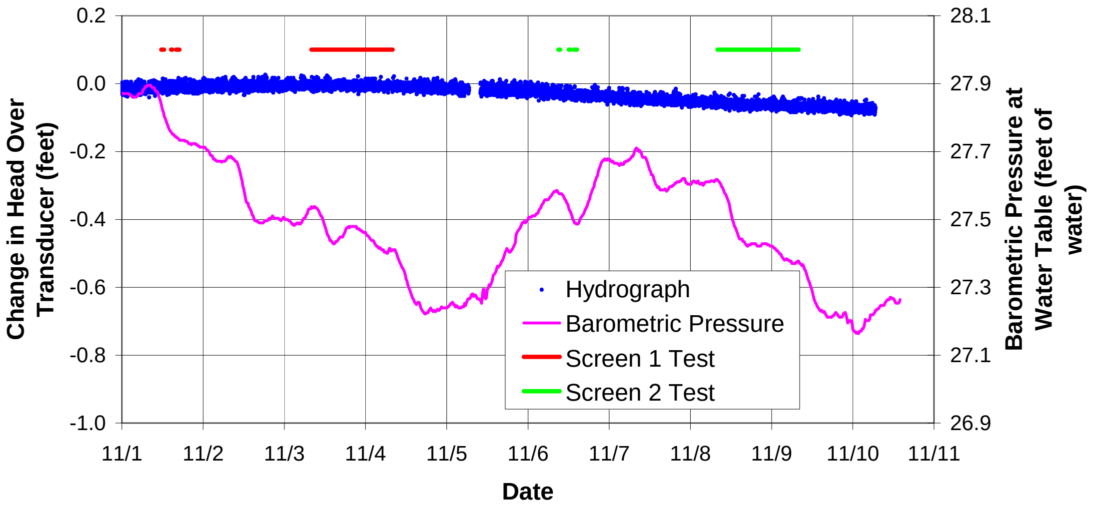

Figure C-7.0-7 Comparison of R-42 apparent hydrograph and adjusted TA-54 barometric pressure

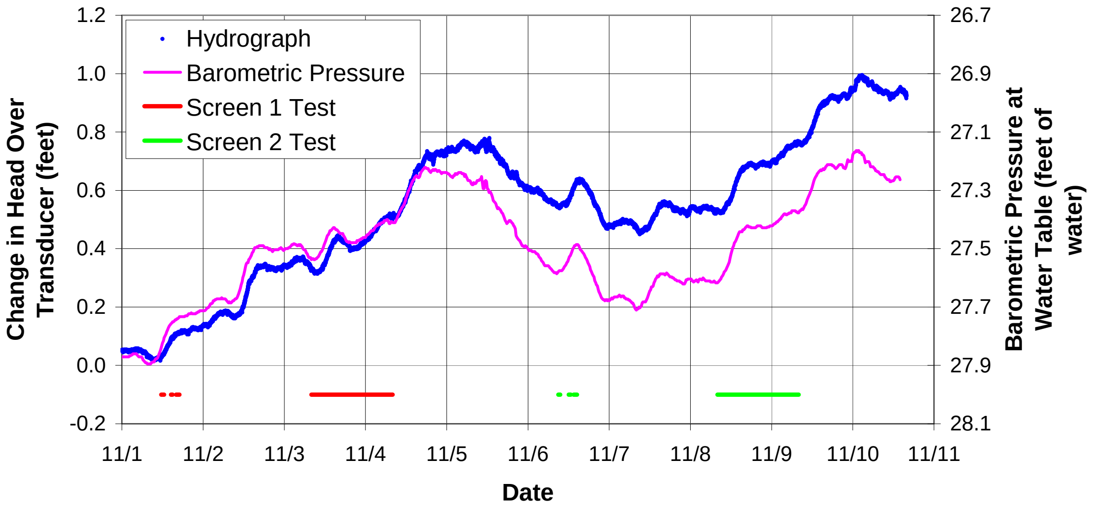

Figure C-7.0-8 Comparison of SCI-2 hydrograph and adjusted TA-54 barometric pressure

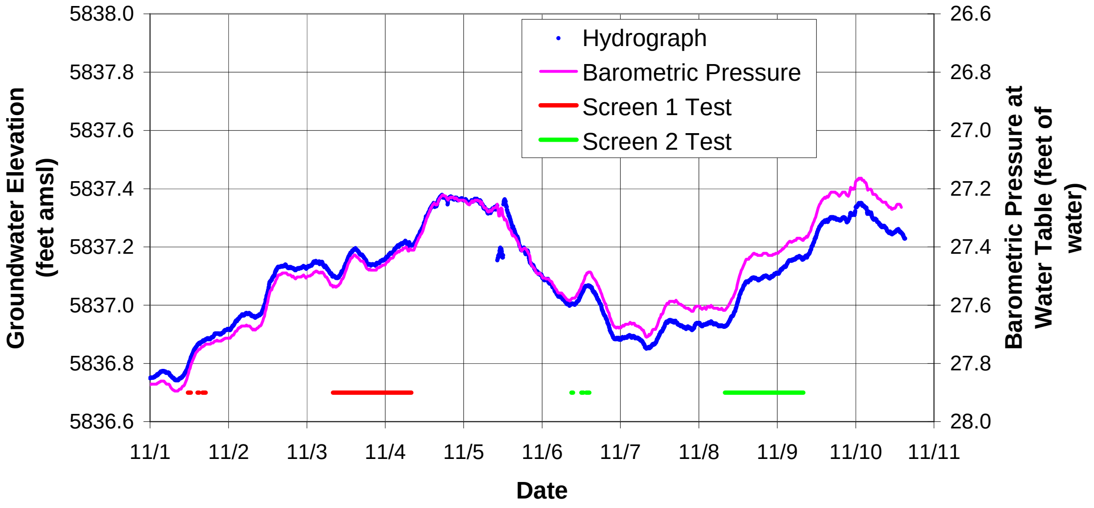

Figure C-7.0-9 Comparison of R-11 hydrograph and adjusted TA-54 barometric pressure

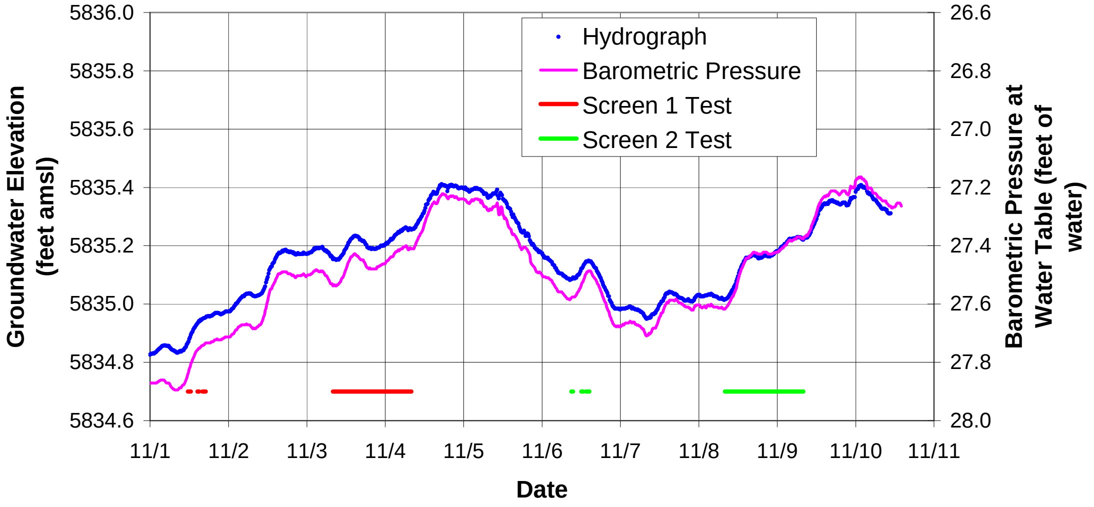

Figure C-7.0-10 Comparison of R-13 hydrograph and adjusted TA-54 barometric pressure

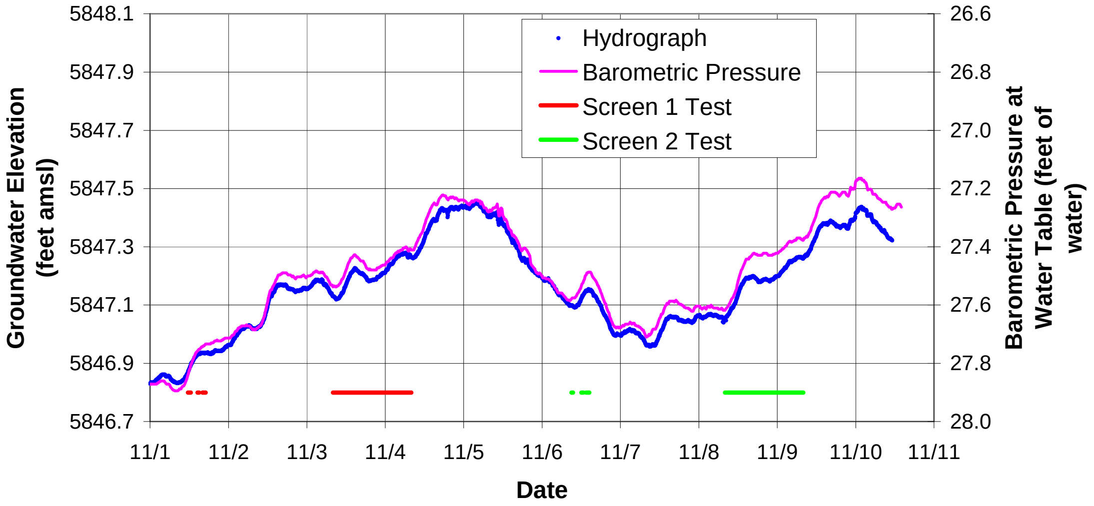

Figure C-7.0-11 Comparison of R-15 hydrograph and adjusted TA-54 barometric pressure

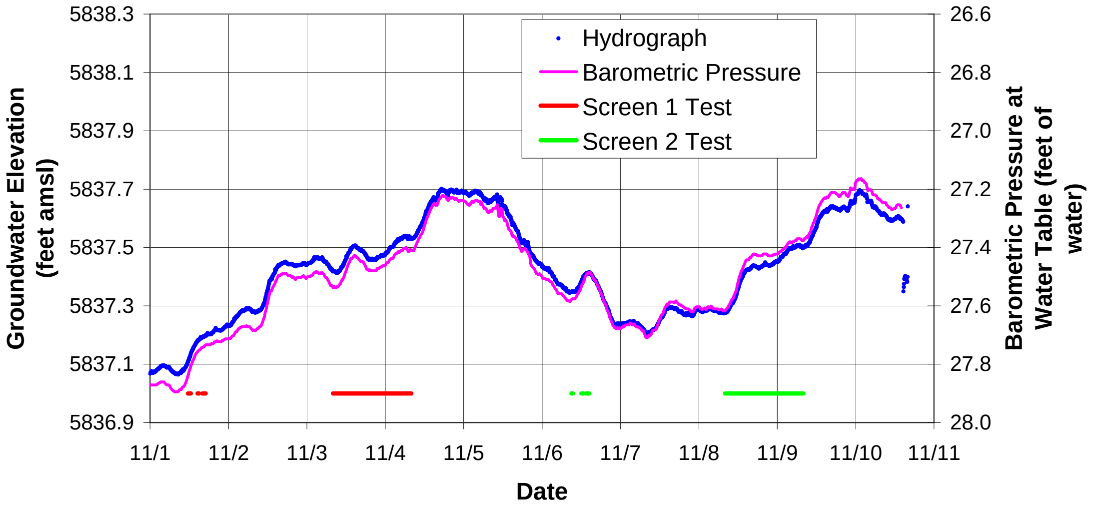

Figure C-7.0-12 Comparison of R-28 hydrograph and adjusted TA-54 barometric pressure

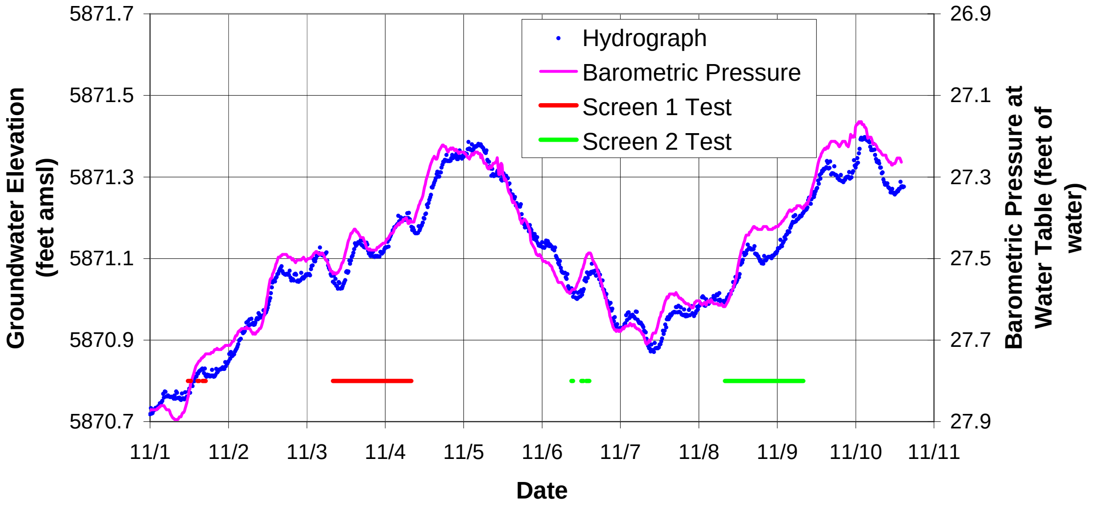

Figure C-7.0-13 Comparison of R-33 screen 1 hydrograph and adjusted TA-54 barometric pressure

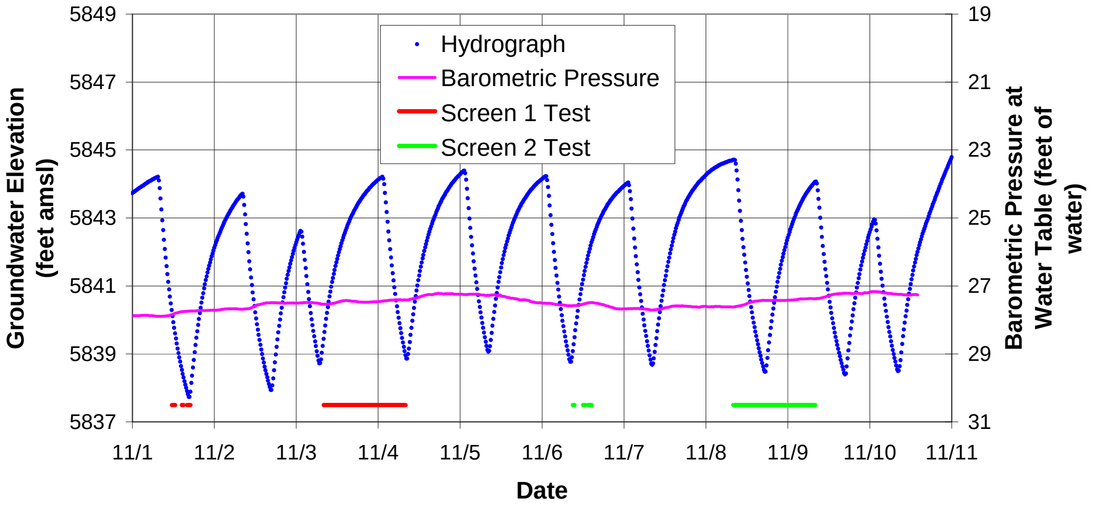

Figure C-7.0-14 Comparison of R-33 screen 2 hydrograph and adjusted TA-54 barometric pressure

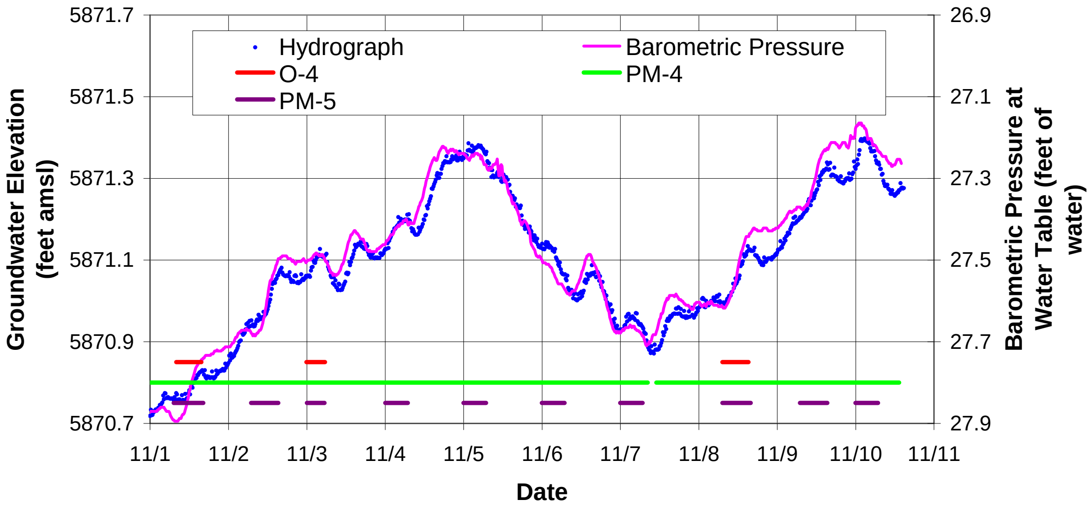

Figure C-7.0-15 **Comparison of R-33 screen 1 hydrograph and municipal well operation**

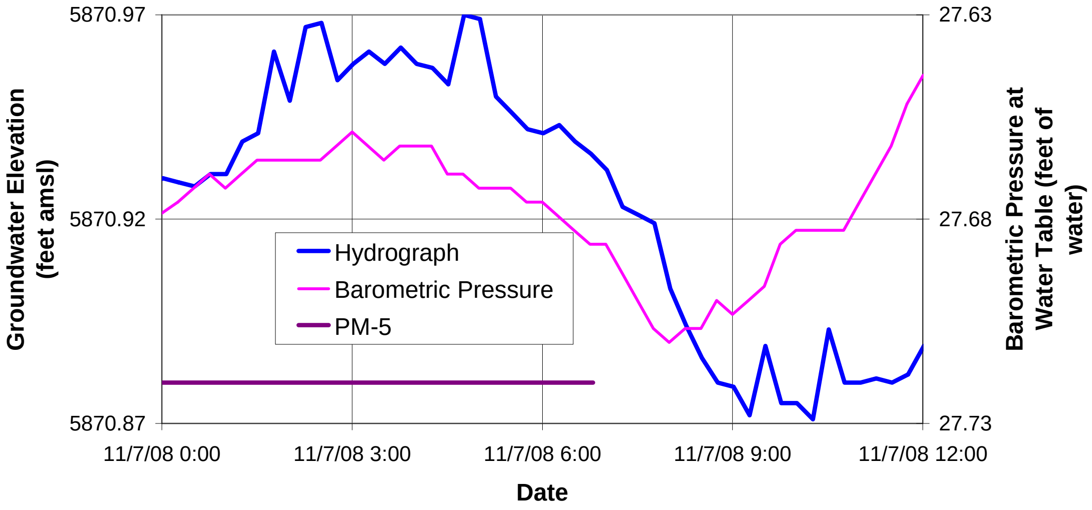

Figure C-7.0-16 **Expanded view of R-33 screen 1 hydrograph for November 7**

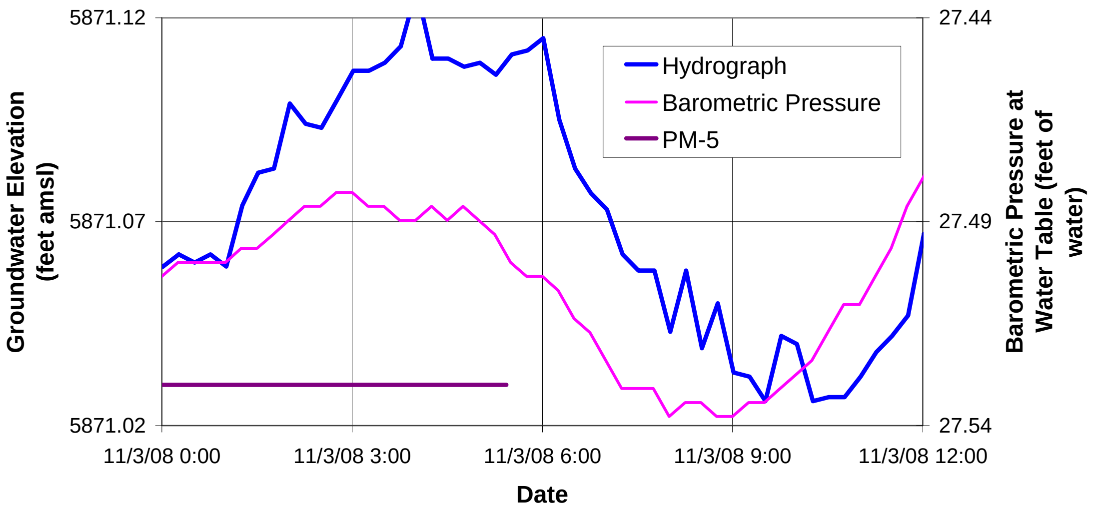

Figure C-7.0-17 Expanded view of R-33 screen 1 hydrograph for November 3

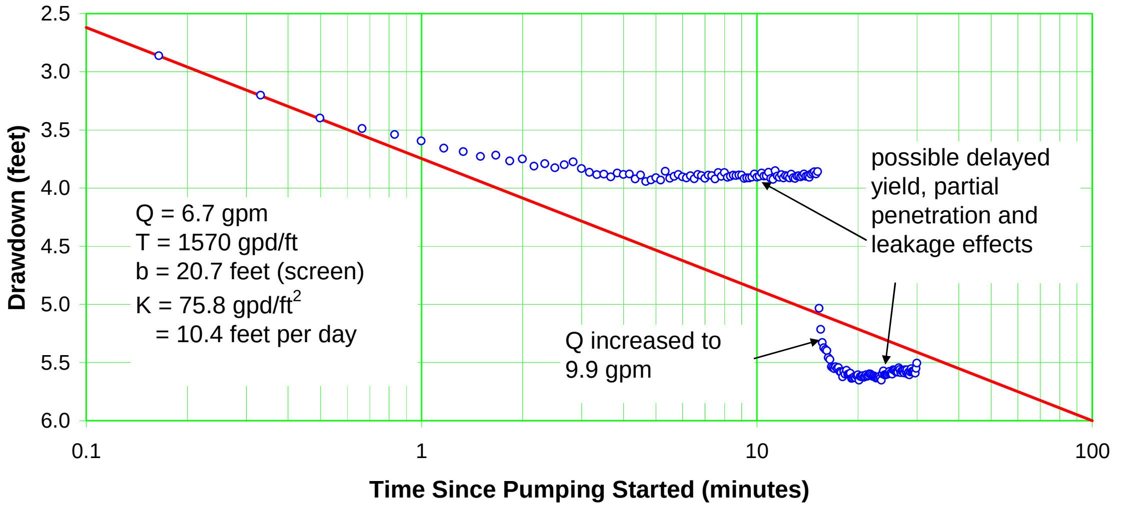

Figure C-8.0-1 Well R-43 screen 1 trial 1 drawdown

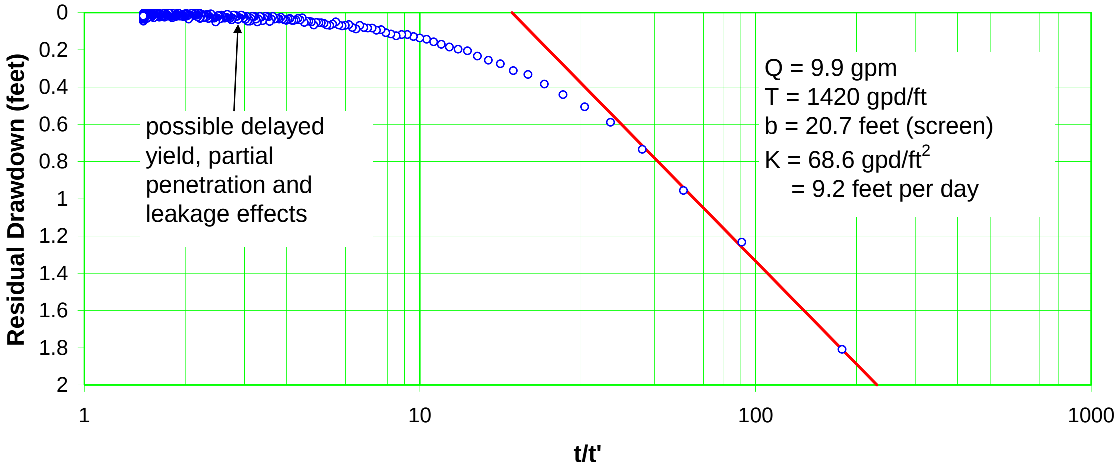

Figure C-8.0-2 Well R-43 screen 1 trial 1 recovery

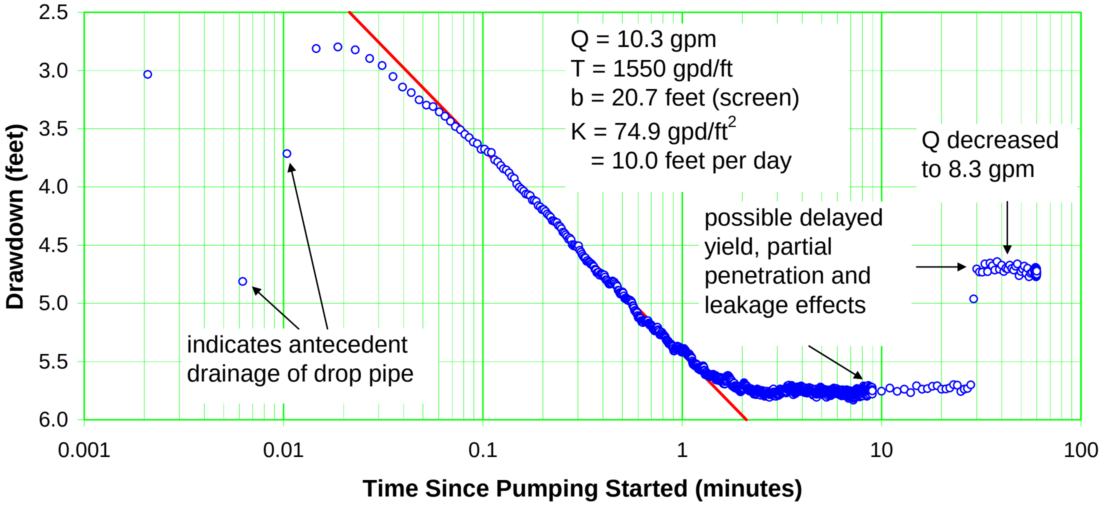

Figure C-8.0-3 Well R-43 screen 1 trail 2 drawdown

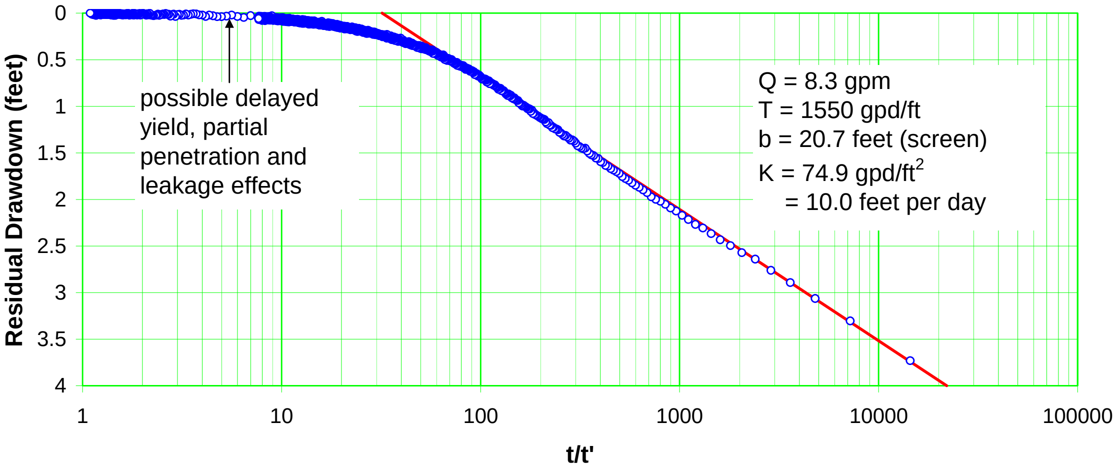

Figure C-8.0-4 Well R-43 screen 1 trial 2 recovery

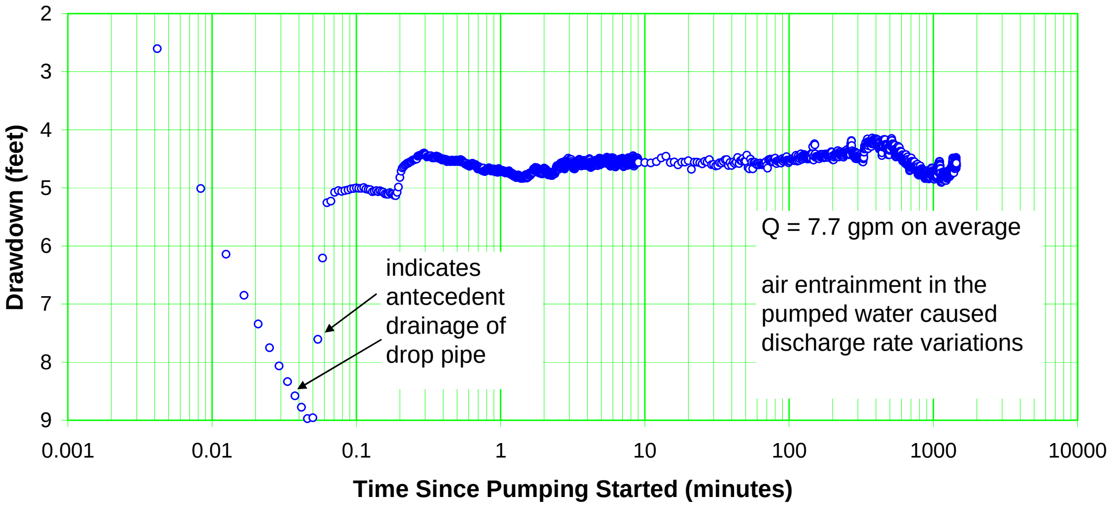

Figure C-8.1-1 Well R-43 screen 1 drawdown

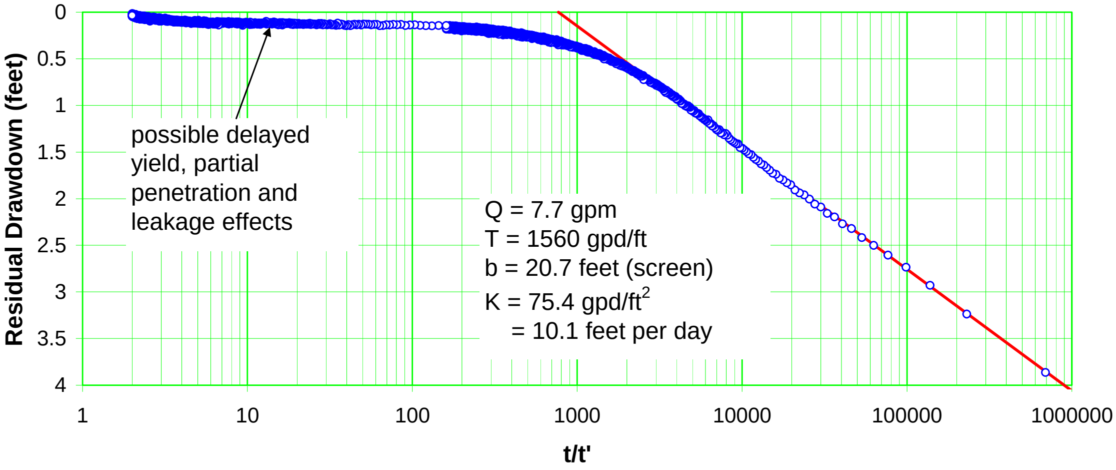

Figure C-8.1-2 Well R-43 screen 1 recovery

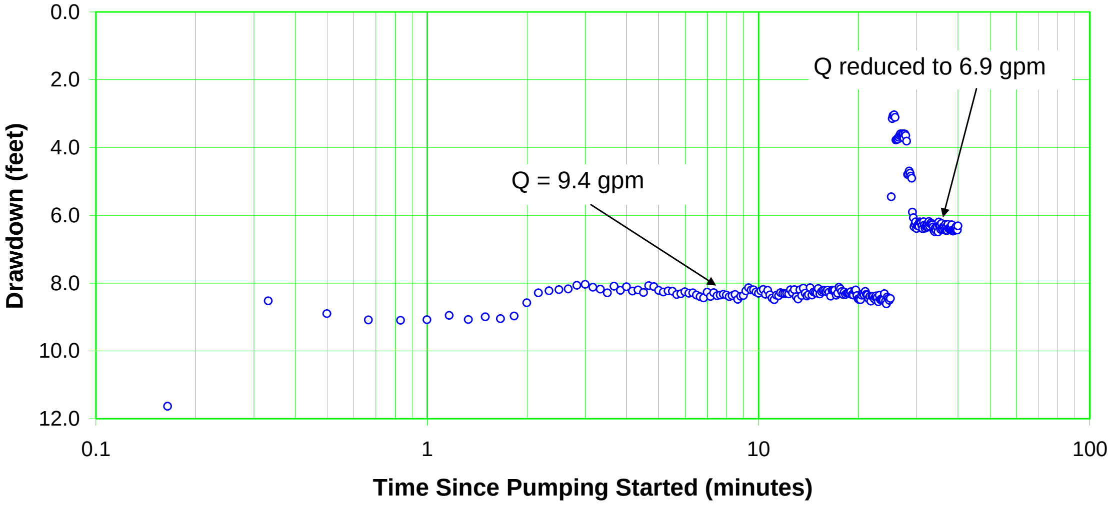

Figure C-9.0-1 Well R-43 screen 2 trial 1 drawdown

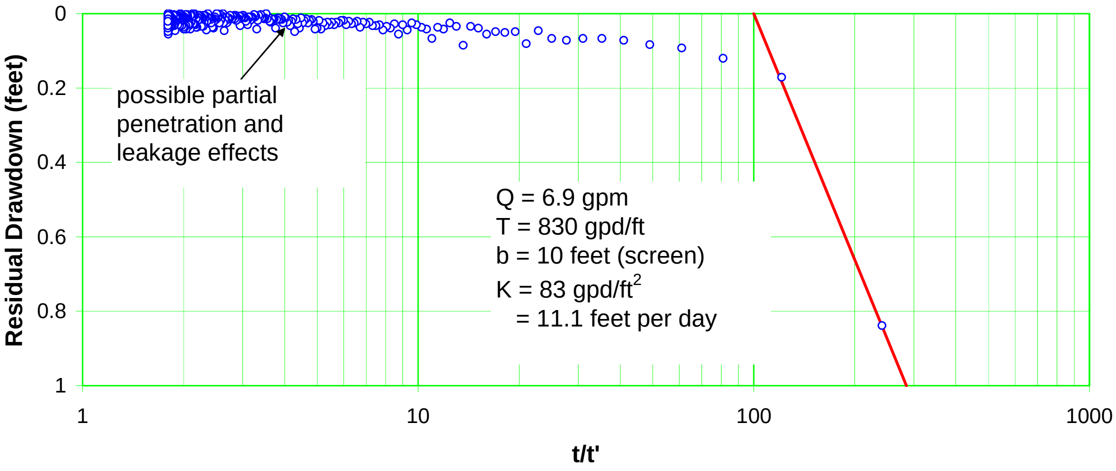

Figure C-9.0-2 Well R-43 screen 2 trial 1 recovery

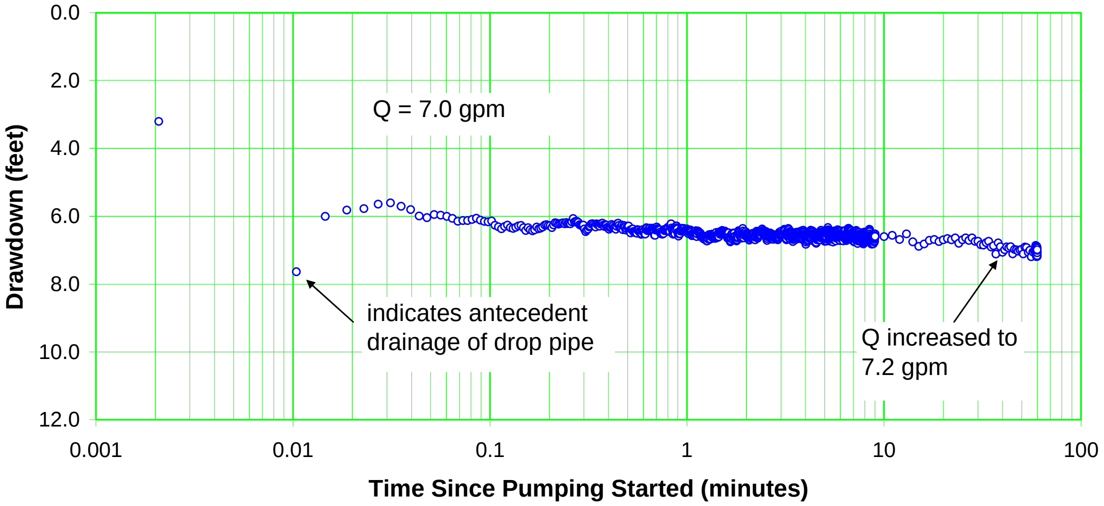

Figure C-9.0-3 Well R-43 screen 2 trial 2 drawdown

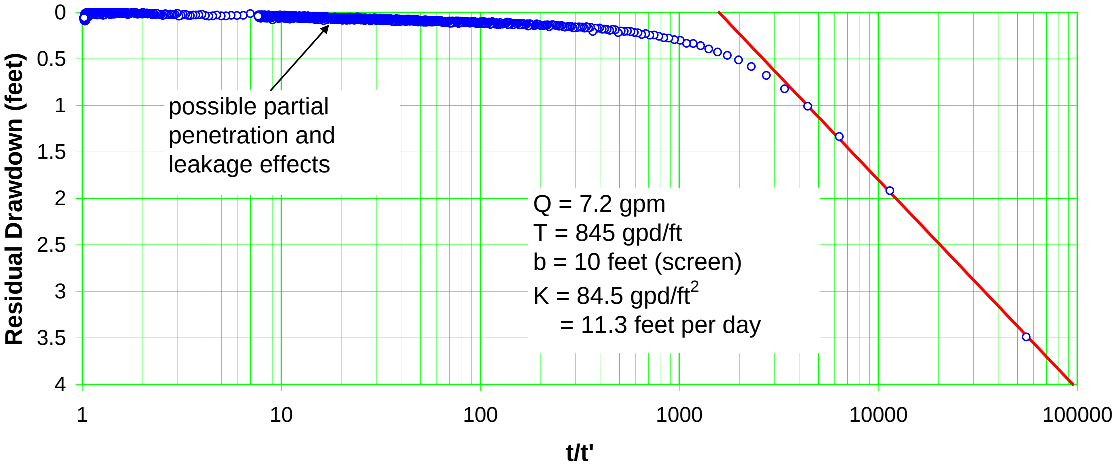

Figure C-9.0-4 Well R-43 screen 2 trial 2 recovery

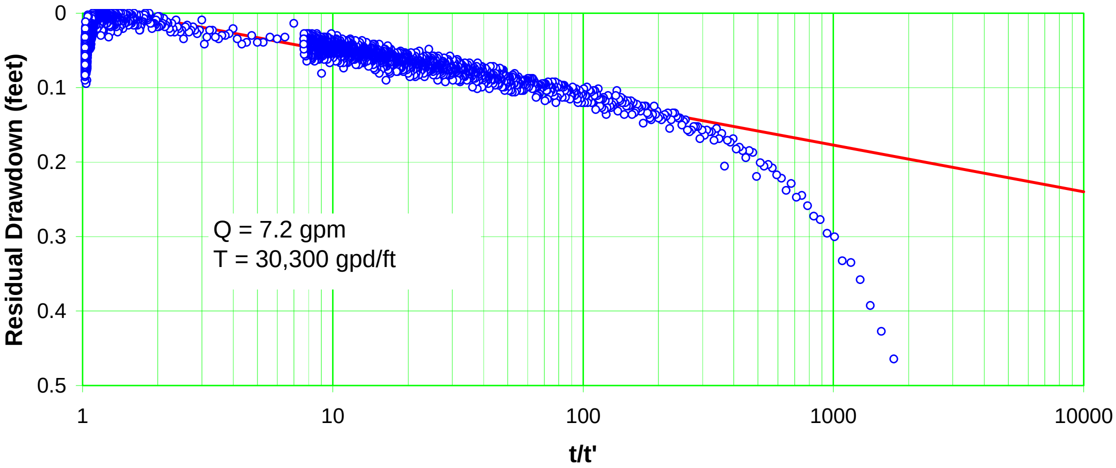

Figure C-9.0-5 Well R-43 screen 2 trial recovery-late data

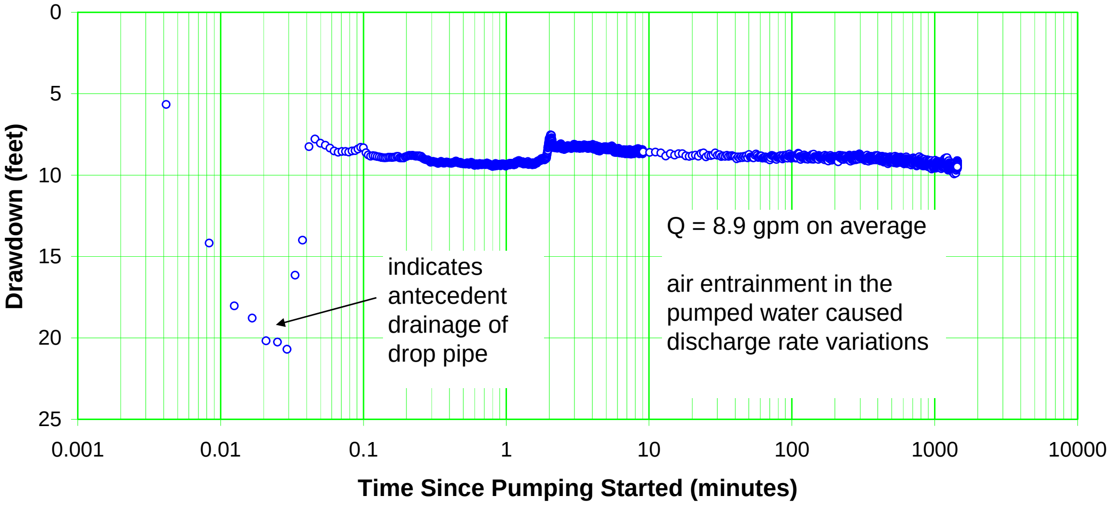

Figure C-9.1-1 Well R-43 screen 2 drawdown

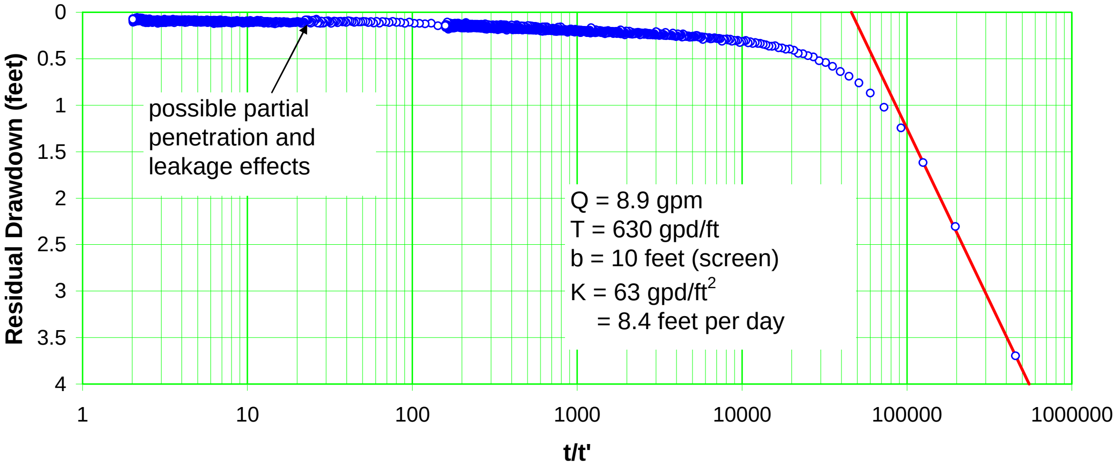

Figure C-9.1-2 Well R-43 screen 2 recovery

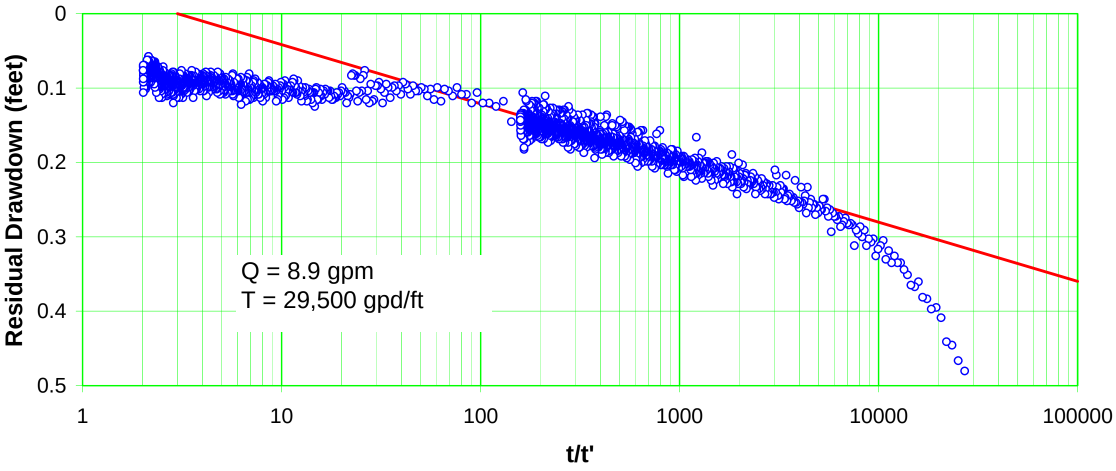

Figure C-9.1-3 Well R-43 screen 2 recovery-late data

Table C-8.3-1
R-43 Screen 1 Hydraulic Conductivity Values

Test	Hydraulic Conductivity (ft/d)
Trial 1 Drawdown	10.4
Trial 1 Recovery	9.2
Trial 2 Drawdown	10.0
Trial 2 Recovery	10.0
24-h Recovery	10.1
Average	**9.9**

Table C-9.3-1
R-43 Screen 2 Hydraulic Conductivity Values

Test	Hydraulic Conductivity (ft/d)	Transmissivity (gpd/ft)
Trial 1 Early Recovery	11.1	na*
Trial 2 Early Recovery	11.3	na
24h Early Recovery	8.4	na
Trial 2 Intermediate Recovery	na	30,300
24-h Intermediate Recovery	na	29,500
Average	**10.3**	**29,900**

*na = Not available.

Appendix D

Borehole Video Logging (on DVDs included with this document)

Appendix E

Los Alamos National Laboratory Geophysical Logs (on CD included with this document)

Appendix F

Screen-Interval Selection

F-1.0 SCI-2 INTERMEDIATE AND R-43 REGIONAL WELL OBJECTIVES (AUGUST 5, 2008)

Core hole SCI-2 was completed to a depth just above the regional water table at a point close to and southeast of former core hole SCC-2 in Sandia Canyon. The goals for SCI-2 were to (1) collect core samples for analysis of metals and anions leachable by deionized (DI) water and nitric acid per U.S. Environmental Protection Agency Method 3050, (2) investigate the presence and nature of perched water, and (3) provide the information necessary to determine whether the best well completion at this location should be a perched intermediate well (SCI-2) or if a regional well (R-43) should be designed. Core hole SCI-2 was initially planned to extend as far as the regional water table to obtain a water sample, and Los Alamos National Laboratory extended its targeted depth to the regional aquifer in an attempt to get groundwater samples. However, difficulties in coring (refusal) required that drilling be stopped just short of the predicted top of regional saturation. Core recovery was obtained from these lower depths and were leached and tested for contaminants of concern. Even though the regional aquifer could not be reached, all the coring and sample collection objectives (including video and geophysical logging) for SCI-2 were successfully completed.

F-2.0 OBSERVATIONS

During drilling, no persistent perched intermediate groundwater was recognized, with the exception of a minor and short-lived show of water at the top of the Cerros del Rio basalt. That groundwater was not present long enough or in sufficient quantity for sample collection and may have been related to the introduction of potable water used during drilling through the overlying units.

No perched water was detected during coring of the Cerros del Rio basalt, but groundwater characterization was hindered by introduction of water to cool the core bit and by the lack of circulation below the top of the basalt. To better characterize potential perched groundwater, the decision was made to collect a borehole video log and an induction log in the open borehole after coring to total depth was completed. Coring was terminated when refusal was encountered at a depth of 890 ft. Tagging for water showed the borehole was dry at 890 ft. With coring completed, plans were made to pull the casing back so that the video and induction logs could be collected. Before pulling the core casing back, hydrated bentonite was tremied into the borehole from 850 to 875 ft to isolate the regional aquifer from any potential perched groundwater that might be sealed off behind the drill casing. After the bentonite was allowed to cure for 12 h, the casing was pulled back to the top of the basalt and the video log was run.

The video log revealed groundwater entering the borehole via fractures and interflow breccias in the basalt below a depth of 509.4 ft. Flow of groundwater into the borehole was observed to increase downhole, reaching maximum flow rate at a depth 564.5 ft. The water level at the time the video log was run on August 1, 2008, was 570 ft. Gamma and induction logs were collected after the borehole video. Geologic contacts encountered during drilling and results of the gamma and induction logs are summarized in Figures F-2.0-1 and F-2.0-2 Following the logging activities, a water sample was collected for quick turnaround anion and cation analyses; a sample split was collected for the New Mexico Environment Department Department of Energy Oversight Bureau. The water level was then monitored for 3 d, and it stabilized at a depth of 561.3 ft.

After a first review of the data, the decision was made to direct the subcontractor to add bentonite chips up into the base of the Cerros del Rio lavas to 625-ft depth to seal off and prevent movement of chromium-contaminated water into the Puye Formation below the basalts. This work was scheduled for August 5. Water levels will again be monitored after these chips are added.

The screening groundwater sample was collected from standing water in the SCI-2 borehole from a depth just below 590 ft, within the Cerros del Rio basalt. It is believed that this water represents water flowing into the borehole from above via fractures and interflow zones in the interval from 509- to 580-ft depth. This sample contains elevated (above-background) dissolved concentrations of total chromium (503 ppb), chloride (47.4 ppm), nitrate(as N) (4.41 ppm), and sulfate (72.9 ppm). Background dissolved concentrations of total chromium, chloride, nitrate(N), and sulfate are less than 5 ppb, 3 ppm, 0.5 ppm, and 4 ppm, respectively, within perched intermediate depth groundwater. The groundwater is probably relatively oxidizing, based on the observed contaminant concentrations. It is likely that most of the chromium in the water sample is present as soluble chromium(VI), in the form of chromate (CrO_4^{-2}). The high concentrations of chromium, chloride, nitrate(N), and sulfate are similar to the contaminants found in alluvial groundwater and in pore water of the overlying unsaturated zone, suggesting a source of contamination in the headwaters of Sandia Canyon.

Figure F-2.0-3 shows profiles of American Society for Testing and Materials (ASTM) moisture analysis (panel F-2.0-3a) and DI water leach results (panels F-2.0-3b–e) for pore water from the core samples collected at SCI-2. Leach tests were conducted for 48 h before filtering, sample preservation, and chemical analyses at the Hydrology, Geochemistry, and Geology Group. Results of the DI leach test suggest that residual chromium is present in pore water at elevated concentrations in the lower vadose zone beneath Sandia Canyon. Concentrations of total dissolved chromium and hexavalent chromium exceeding 0.05 and 0.02 mg/L, respectively, with high chromium(VI)/Cr_t ratios greater than 20%, occur in the Puye Formation and Cerros del Rio basalt. Chromium concentrations in pore water most likely represent a combination of natural and anthropogenic sources, with a higher natural background occurring within the Cerros del Rio basalt relative to overlying and underlying rock units. The highest concentration of total dissolved chromium (0.323 mg/L) occurs within the Cerros del Rio basalt in a core sample at 483.5–484.5 ft, whereas the highest concentration of chromium(VI) (0.173 μg/g) occurs within the lower Puye Formation at 686.3-687.3 ft (Figure F-2.0-3c). Peak concentrations of total chromium are associated with those for nitrate, as well as sulfate, in SCI-2 (Figures F-2.0-3b, d, and e).

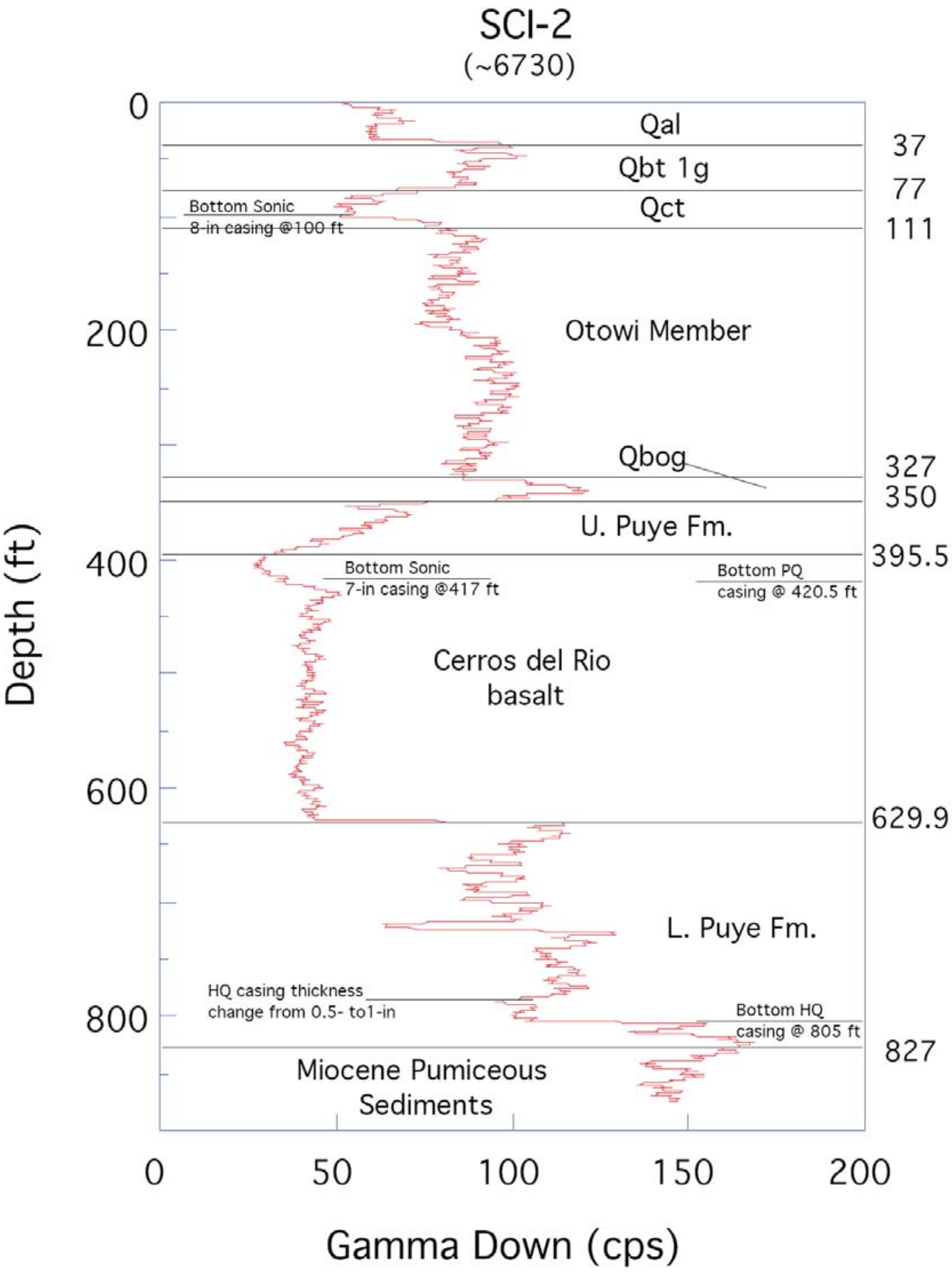

Figure F-2.0-1 **Gamma log of cased borehole SCI-2**

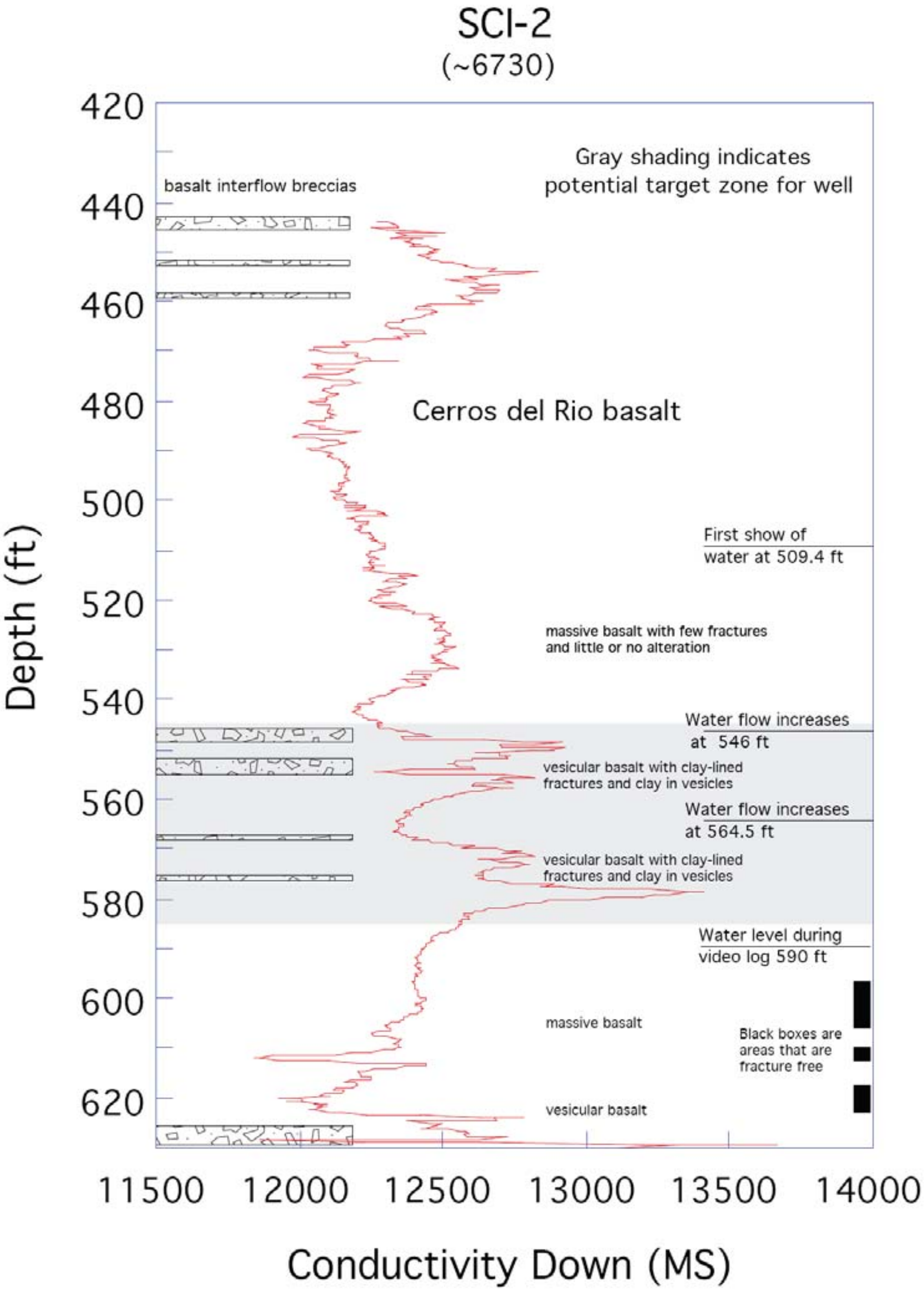

Figure F-2.0-2 Conductivity profile of open borehole interval at SCI-2

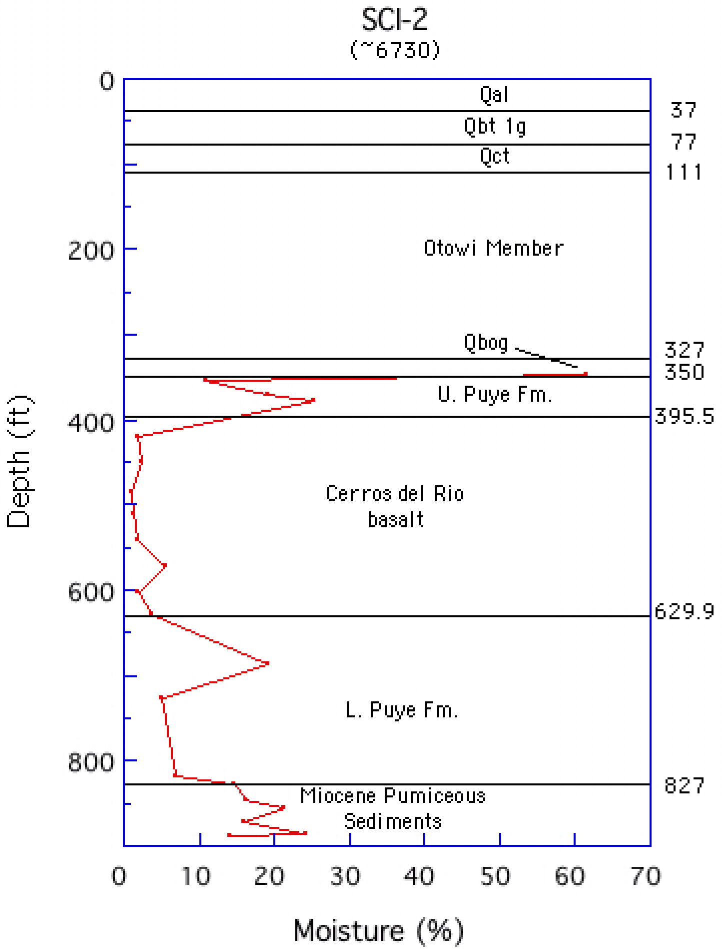

Figure F-2.0-3a Moisture (ASTM weight by percent) profile in SCI-2

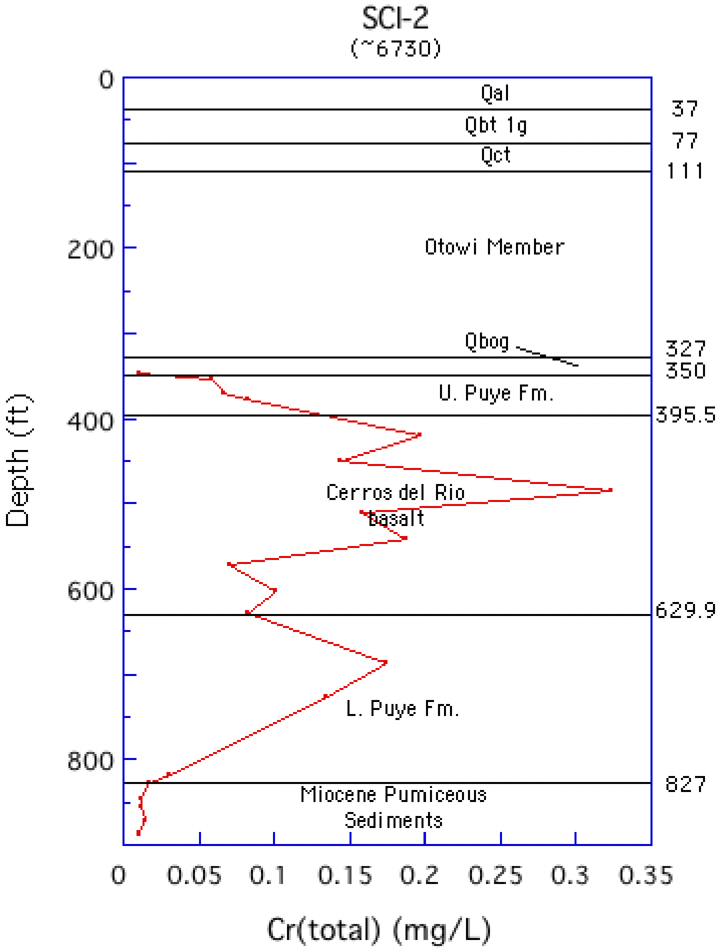

Figure F-2.0-3b **Total chromium concentration profile (DI leach normalized to concentration in pore water) in SCI-2**

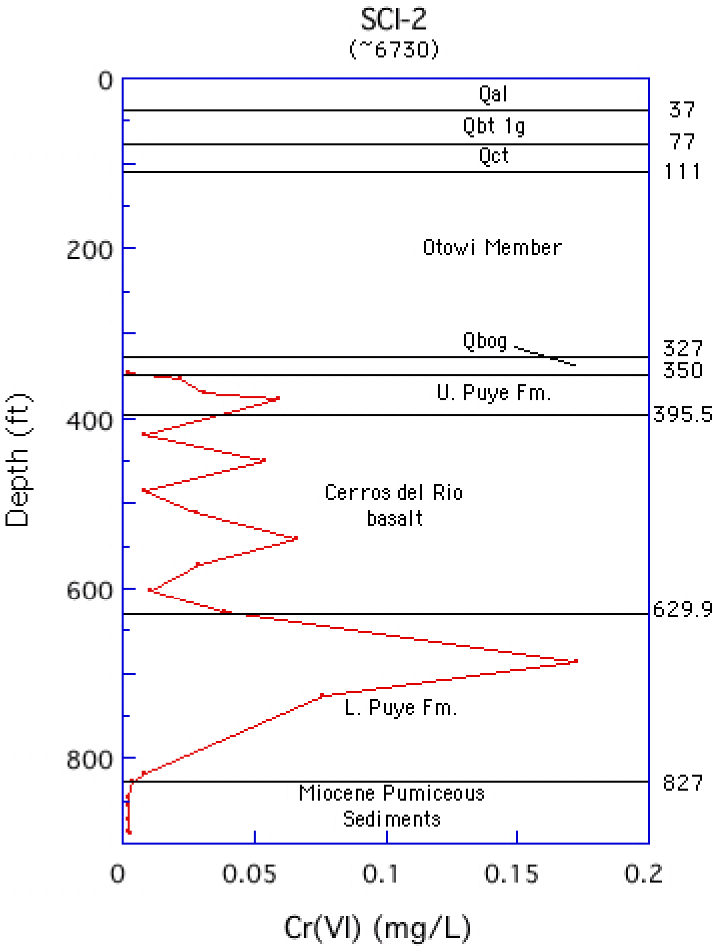

Figure F-2.0-3c **Hexavalent chromium concentration profile (DI leach normalized to concentration in pore water) in SCI-2**

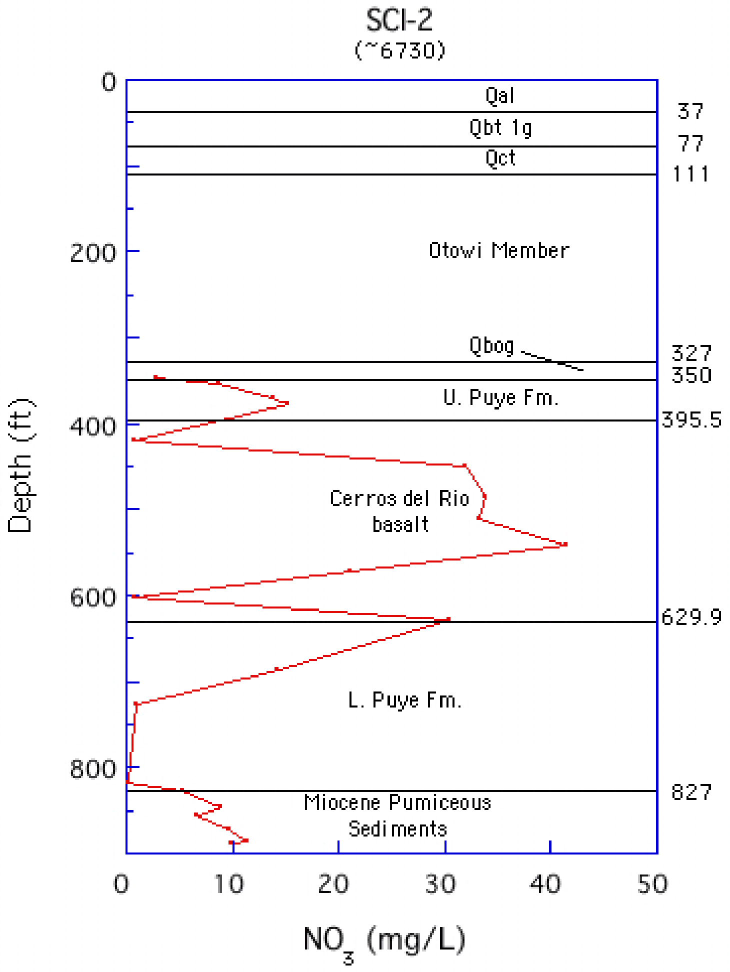

Figure 2-0.3d **Nitrate concentration profile (DI leach normalized to concentration in pore water) in SCI-2**

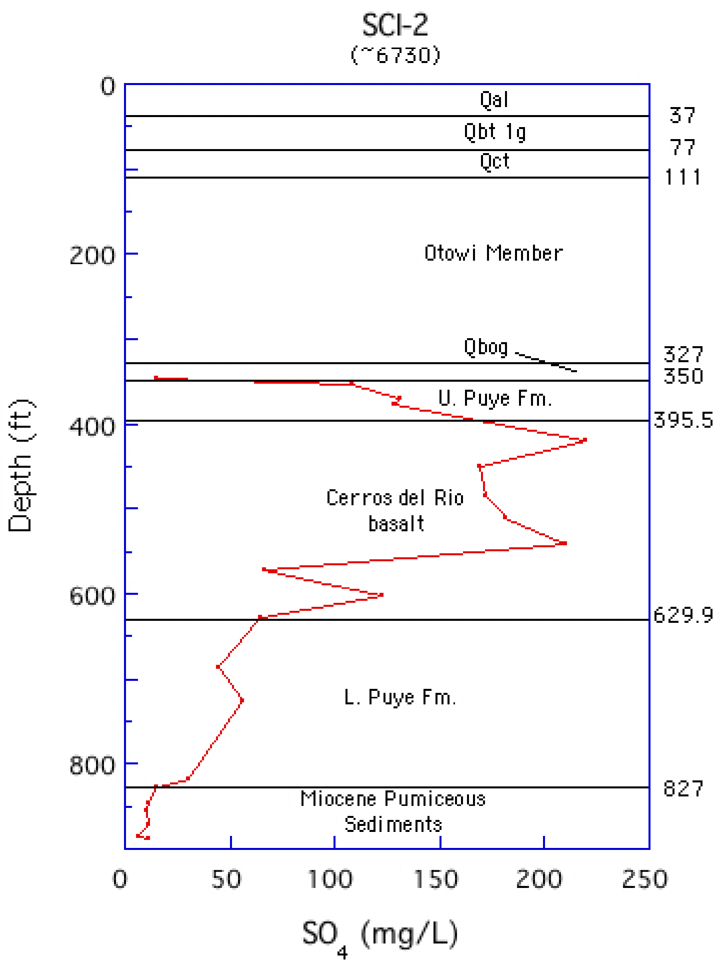

Figure F-2.0-3e Sulfate concentration profile (DI leach normalized to concentration in pore water) in SCI-2