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Completion Report for Regional Aquifer Well R-39

Los Alamos
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Prepared by the Environmental Programs Directorate

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April 2009

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EXECUTIVE SUMMARY

The purpose of well R-39 is to provide detection monitoring for potential releases of hazardous or radioactive chemicals from Material Disposal Area (MDA) G at Technical Area 54.

The "Drilling Work Plan for Regional and Intermediate Wells at Technical Area 54" states that "R-39 shall be drilled 150 ft into the regional aquifer, and [a] single completion well will be installed in the uppermost transmissive zone that is identified as optimal based on variations in production and on stratigraphic considerations within the Cerros del Rio basalt." Based on well R-22, located 689 ft north of R-39, the R-39 borehole and well were expected to remain in basalt and the regional groundwater was expected to be at 815 ft below ground surface (bgs).

R-39 was drilled and completed from October 22, 2008, to November 23, 2008, and was drilled to a total depth of 896 ft bgs, extending approximately 70 ft into the saturated portion of the regional aquifer. Groundwater-screening samples were collected during drilling and well development. Open-borehole geophysical logging was conducted to aid well design. A single-completion well was installed in the borehole and a 10-ft screen was positioned from 859.03 to 869.03 ft bgs.

This well completion report describes site preparation, drilling, sampling, well installation, well completion, well development, aquifer testing, surface completion, geodetic survey, and permanent pump installation. Initial groundwater characterization sampling from the competed well was conducted on February 19, 2009, by the Los Alamos Water Stewardship Program in accordance with the March 1, 2005, Compliance Order on Consent. Ongoing activities include waste management and site restoration.

CONTENTS

Figures

Tables

Appendixes

1.0 INTRODUCTION

Los Alamos National Laboratory (LANL or the Laboratory) is a multidisciplinary research facility that is located in north-central New Mexico, approximately 60 mi northeast of Albuquerque and 20 mi northwest of Santa Fe. The Laboratory site covers 40 mi^2 of the Pajarito Plateau, which consists of a series of fingerlike mesas separated by deep canyons containing perennial and intermittent streams running from west to east. Mesa tops range in elevation from approximately 6200 to 7800 ft above sea level.

Technical Area 54 (TA-54) is used for the management of radioactive solid and hazardous chemical wastes pursuant to the Laboratory’s Resource Conservation and Recovery Act (RCRA) Hazardous Waste Facility Permit. TA-54 consists of Material Disposal Areas (MDAs) G, H, J, and L atop Mesita del Buey on the Pajarito Plateau (Figure 1.0-1). These four MDAs, consisting of underground pits, shafts, and trenches that contain hazardous chemicals and radionuclides, are located within the unsaturated units of Bandelier Tuff. MDA H is no longer being used; MDAs L and G currently are accepting wastes.

Well R-39 is one of several regional aquifer wells at TA-54 installed for groundwater monitoring to comply with the RCRA permit. Regional aquifer well R-39 is located southeast of MDA G (Figure 1.0-2).

Well R-39 was proposed in the “Technical Area 54 Well Evaluation and Network Recommendations, Revision 1” (LANL 2007, 098548) and “Drilling Work Plan for Regional and Intermediate Wells at Technical Area 54” (LANL 2007, 099662). The New Mexico Environment Department (NMED) approved these documents in 2007 (NMED 2007, 099257). This completion report summarizes the site preparation, drilling and sampling, well installation, and well completion activities for well R-39, in accordance with the requirements in Section IV.A.3.e.iv of the March 1, 2005, Compliance Order on Consent (the Consent Order).

1.1 Overview of R-39 Well Completion Report

The information presented in this report is 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-39 project, as well as supporting figures, tables, and appendixes.

Section 1 of this completion report describes the site, the purposes of well R-39, and an overview of the installation activities. Section 2 presents the scope of activities for site preparation, drilling, and sampling. Section 3 presents the results of field investigations. Well installation activities and well completion activities are described in sections 4 and 5, respectively. Section 6 explains deviations from planned activities. References and map data sources are provided in section 7.

Appendixes include acronyms and abbreviations, a metric conversion table, and definitions of the data qualifiers used in this report (Appendix A); lithologic log (Appendix B); groundwater analytical results (Appendix C); borehole video logging (Appendix D, on DVD), and Laboratory and Schlumberger geophysical logging results (Appendix E, on CD); and aquifer testing report (Appendix F).

1.2 Overview of Regional Well R-39

The purpose of well R-39 is to provide detection monitoring for potential releases of hazardous or radioactive chemicals from MDA G (Figure 1.0-2). The R-39 borehole was drilled from October 22, 2008, to November 12, 2008, using the fluid-assisted air-rotary drilling method in an open borehole. Well installation activities were completed by November 23, 2008. Well development and aquifer testing activities were completed on December 22, 2008. The NMED well completion date was designated as December 1, 2008. As stipulated by the Consent Order, the R-39 borehole was drilled and the well was installed, causing minimal impact to the in situ characteristics of the regional groundwater.

The R-39 project was performed by Los Alamos Technical Associates, Inc.–Sharp Remediation Services, Inc. (LSRS), for Los Alamos National Security (LANS).

2.0 SCOPE OF ACTIVITIES

All activities were completed in accordance with LANS subcontract 22851-009-08, associated exhibits, Laboratory direction, and LSRS procedures.

2.1 Preliminary Activities

Preliminary activities included preparing administrative planning documents, receiving contractual notice to proceed with field activities, and constructing the drill pad.

2.1.1 Administrative Preparation

The following documents were prepared to support the implementation of the scope of work: “LSRS TA-54 Wells IWD” (Work Document #327703-01); “R-37, R-39, and R-40 Construction Project Storm Water Pollution Prevention Plan Addendum” (LANL 2008); “Waste Characterization Strategy Form for Drilling and Installation of Wells at TA-54 R-37, R-39, and R-40” (Document Catalog Number EP2008-0306). The contract was awarded on May 9, 2008, and the notice to proceed with fieldwork was received on June 16, 2008.

2.1.2 Site Preparation

Site preparation activities were performed between July 16 and 23, 2008, and involved constructing a drill pad north of Pajarito Road and southeast of MDA G (Figure 1.0-2); excavating and lining a cuttings containment pit; and installing berms, silt fencing, and straw waddles to limit stormwater flow and prevent erosion. The drill pad was 20,900 ft^2 and triangular because of its location between the gravel access road to the eastern end of MDA G and an established surface-water channel. The existing gate to the MDA G access road was used to control access to the R-39 drill site. Except for the pit, the pad area was surfaced with base course gravel. The cuttings pit measured approximately 60-ft × 20-ft × 6-ft average depth. Radiation control technicians from the Laboratory’s Radiation Protection Group performed radiological screening of the site before pad construction and of samples and equipment before transport from the site, as needed.

LSRS set up an office trailer and generator, and Water Development Company Exploration & Wells (WDC) mobilized drilling equipment on October 21, 2008. Municipal water for pad construction and drilling activities was obtained from a fire hydrant located at TA-18. A safety fence was installed around the cuttings containment pit, and signs were posted at the entrance to the site to limit access to authorized personnel.

2.2 Drilling Activities

This section describes the drilling strategy and provides a chronology of drilling activities conducted at R-39.

2.2.1 Drilling Strategy

The R-39 borehole was drilled using a Speedstar 50K drilling rig manufactured by George E. Failing & Co. from October 22, 2008, to November 12, 2008. The field crew worked one 10-h shift per day, 10 d on and 4 d off. The borehole was drilled using the fluid-assisted air-rotary drilling method. Except for the surface conductor casing, the borehole was drilled "open" (i.e., without the use of casing). Drilling bits used consisted of a 14.75-in. tricone and a 14.75-in. hammer bit with carbide buttons.

The R-39 borehole was drilled to a total depth (TD) of 896 ft bgs, extending approximately 70 ft into the saturated portion of the regional aquifer. Regional aquifer groundwater was first detected during drilling at 796 ft bgs and stabilized at 826 ft bgs during well development. No perched groundwater was encountered.

From the surface to 707 ft bgs, a relatively thin mixture of municipal water and Baroid AQF-2 foaming agent was injected to cool the bit and help lift cuttings from the borehole. From 707 ft to TD at 896 ft, no foam was added, and only municipal water and air were used as the drilling fluids. This allowed for drilling and completion of the well in the saturated portion of the regional aquifer without using drilling mud or additives. The estimated cumulative total of liquid drilling fluids introduced to and recovered from the borehole is presented in Table 2.2-1.

2.2.2 Chronological Drilling Activities

On October 21, 2008, drilling equipment and supplies were mobilized to the site.

On October 22, 2008, the R-39 borehole was initiated using a 16-in. tricone roller bit and extended to 40.5 ft bgs through the surface alluvium into unit 1g of the Tshirege Member of the Bandelier Tuff (Qbt 1g).

October 23, 2008, 41 ft of 16-in. thin-walled surface conductor casing was installed and cemented in place.

On October 24, 2008, drilling began at 40.5 ft bgs using the 14.75-in. hammer bit and encountered Cerros del Rio basalt at 147 ft bgs.

On October 25, 2008, multiple fractures were encountered in the basalt at 230 ft bgs, and no cuttings were recovered from 310 to 315 ft bgs. Subsequent logging of available cuttings identified basaltic cinder from 307 to 317 ft bgs and basaltic sediments with cinder from 337 to 373 ft bgs.

On October 26, 2008, the borehole advanced within lithologies slightly more felsic than basalt and probably dacitic in composition. At midday, the hammer stopped firing with the borehole at 570 ft bgs. Subsequent evaluation of the hammer revealed a broken piston.

From October 27, 2008, to October 28, 2008, no drilling occurred, pending the arrival of a replacement hammer.

On October 29, 2008, drilling resumed in hard dacitic lava and reached 665 ft bgs at the end of the day. LANL Water Stewardship Program (LWSP) directed that no foam be added to the drilling fluid.

On October 30, 2008, the borehole was advanced to 685 ft bgs and WDC reported the possible presence of perched water, although 9400 gal. of municipal water had been injected since the start of drilling (Table 2.2-1).

From October 31, 2008, to November 3, 2008, activities were suspended for a 4-d break.

On November 4, 2008, the hammer and drill string were removed from the borehole, and water was measured at 642.5 ft bgs. The drill string and tricone bit were tripped back into the borehole, and air was used to blow the water from the hole. After 1 h, the water was measured at 648.5 ft bgs. The tricone bit and drill string were removed.

On November 5, 2008, the tricone bit and drill string were tripped in and water was measured at 665 ft bgs. WDC attempted to air-lift a groundwater-screening sample; however, no water was produced after 1 h of injecting air. The drill string was tripped out and the Laboratory video camera was deployed to search for water in the borehole. No water was observed. The indication of perched water noted on October 30 was determined to be injected municipal water contained by the massive dacitic lava.

On November 6, 2008, drilling resumed using the tricone bit. A small amount of foam (4 gal.) was required to return cuttings to the surface. A depth of 707 ft bgs was reached.

On November 7, 2008, the borehole depth at the end of the day was 714.5 ft bgs; no foam had been added.

On November 8, 2008, a borehole depth of 720 ft bgs was reached, and the drill string was tripped out to replace the tricone bit with the hammer bit.

On November 9, 2008, the hammer was used to advance the borehole to 765 ft bgs.

On November 10, 2008, the hammer was used to advance the borehole to 823 ft bgs.

On November 11, 2008, water was not detected within the drill string using the depth to water (DTW) meter. LWSP had predicted the regional groundwater in the R-39 borehole at 815 ft bgs. The hammer was used to advance the borehole to 868 ft bgs and the drill string was tripped out.

On November 12, 2008, regional groundwater was measured at 796 ft bgs. WDC air-lifted a groundwater-screening sample and collected several water-level measurements at 806 ft bgs over several hours. Drilling resumed and encountered flowing fine felsic sand at 895 ft bgs. Drilling was halted at 896 ft bgs due to concerns about open-borehole stability. LWSP was contacted; it directed that drilling be stopped and the R-39 well installed in the open borehole. Schlumberger, Inc., was called to perform open-borehole geophysical logging to aid the well design.

2.3 Sampling Activities

The following sampling activities were performed at R-39.

Drill cuttings were collected at 5-ft intervals from the cuttings discharged into the lined cuttings containment pit. The cuttings were examined to characterize the lithology and stratigraphy of the R-39 borehole and to generate the lithologic log in Appendix B.

A groundwater-screening sample was collected upon encountering saturation in the regional aquifer and analyzed for volatile organic compounds (VOCs), NMED high explosives, and low-level tritium at off-site laboratories and for dissolved cations/metals and anions at the Laboratory’s Earth and Environmental Science Division–Hydrology, Geochemistry, and Geology Group (EES-14) chemistry laboratory.

A predevelopment groundwater-screening sample was collected after well installation and analyzed for low-level tritium at an off-site laboratory and for dissolved cations/metals and anions at the EES-14 chemistry laboratory.

Development water was sampled during pumping and measured for the following water parameters: pH, specific conductivity (SP), temperature (T), turbidity, dissolved oxygen (DO), and salinity. In addition, samples were collected and submitted for total organic carbon (TOC) analysis at the EES-14 chemistry laboratory.

Waste characterization samples were collected of the cuttings and drilling water discharged into the lined cuttings containment pit and of well development water discharged to a 21000-gal. storage tank.

LWSP collected a full suite groundwater sample on February 19, 2008, following installation of the permanent pump and sampling system in the R-39 well.

Sampling documentation and containers were provided by the Laboratory and processed through the Laboratory's Sample Management Office. Groundwater analytical results and details of groundwater chemistry at R-39 are presented in Appendix C. Table 2.3-1 presents a summary of all groundwater samples collected to date at well R-39.

2.4 Geophysical Testing

On October 30, 2008, the borehole depth was 685 ft bgs, and WDC had indicated that perched water might be present. On November 5, 2008, following a 4-d break, the Laboratory's downhole video camera was used to search for perched water in the borehole

On November 13, 2008, Schlumberger, Inc., performed geophysical logging of the open borehole (Appendix E). The logging suite consisted of Accelerator Porosity Sonde (neutron porosity), array induction, combined magnetic resonance, natural and spectral gamma, Elemental Capture Sonde, and Formation Micro-Imager. The geophysical logging was used to further define lithologic contacts (Appendix B) and design the R-39 well. Additionally, the Laboratory reran the borehole video down to the regional aquifer (Appendix D).

Table 2.4-1 lists the video and geophysical logging performed at R-39.

3.0 FIELD INVESTIGATION RESULTS

3.1 Geology and Hydrogeology

A brief description of the geologic and hydrogeologic features encountered at R-39 is presented in Appendix B. The Laboratory's geology task leader and site geologists examined cuttings and geophysical logs to determine geologic contacts. Drilling observations, video logging, water-level measurements, and geophysical logs were used to characterize the regional groundwater encountered at R-39.

3.1.1 Stratigraphy

The stratigraphy for the R-39 borehole is presented in order of youngest to oldest geologic units. Lithologic descriptions are based on samples of discharged cuttings. Cuttings and borehole geophysical logs were used to identify geologic contacts. Figure 3.1-1 illustrates the stratigraphy at R-39. A detailed lithologic log is presented in Appendix B.

Quaternary Alluvium, Qal (0–25 ft bgs)

Quaternary alluvium consisting of loamy soil and silty sand with volcaniclastic gravel and pebbles was encountered from 0 to 25 ft bgs. No evidence of alluvial groundwater was observed.

Cooling Unit 1g, Tshirege Member of the Bandelier Tuff, Qbt 1g (25–77 ft bgs)

Cooling unit 1g of the Tshirege Member of the Bandelier Tuff is present at R-39 from 25 to 77 ft bgs. Unit 1g is a glassy, lithic-bearing, pumiceous, poorly welded ash-flow tuff. At its upper contact, the unit is reddish gray and moderately indurated and typically transitions within 10 to 20 ft to a light pinkish gray, less indurated (softer) ash-flow tuff. It contains reddish gray to gray, subangular to subrounded, intermediate composition volcanic rocks (lithics) up to 15 mm in diameter. Light olive-green vitric pumice lapilli have a waxy luster and well-developed flow-tube structure. The lapilli are harder than the surrounding tuff matrix.

Otowi Member of the Bandelier Tuff, Qbo (77–139 ft bgs)

The Otowi Member of the Bandelier Tuff is present in R-39 from 77 to 139 ft bgs. The Otowi Member is a glassy, lithic-bearing, pumiceous, poorly welded ash-flow tuff. It contains reddish gray to gray, subangular to subrounded, intermediate composition volcanic rocks up to 15 mm in diameter. Vitric pale yellow to white pumice lapilli contain conspicuous phenocrysts of quartz and sanidine.

Guaje Pumice Bed of the Otowi Member of the Bandelier Tuff, Qbog (139–147 ft bgs)

The Guaje Pumice Bed is present from 139 to 147 ft bgs. The pumice bed contains abundant pumice fragments (up to 97%) with subordinate amounts of volcanic lithics, quartz and sanidine phenocrysts, trace mafic minerals, and fine ash.

Cerros del Rio Basalt (147–373 ft bgs)

Cerros del Rio basalt, from 147 to 373 ft bgs, consists of multiple lava flows of vesicular to massive porphyritic basalt with an aphanitic groundmass. Local cinder and basaltic sedimentary deposits may represent interflow horizons. Basaltic cinder is especially abundant from 307 to 373 ft bgs. Basalt ranges from dark to medium gray; cinder is typically red to reddish gray.

Cerros del Rio Dacitic Lavas, Cinder Beds, and Underlying Felsic Sand (373–896 ft bgs)

Cerros del Rio dacitic cinder is prominent from 373 to 465 ft bgs, associated with mafic sand from 465 to 505 ft bgs. Medium gray, vesicular to massive dacitic lavas with aphanitic groundmass extend from 505 to 864 ft bgs, with minor intercalated cinder and mafic sediment. Rounded and reworked dacitic gravels occur beneath lava, from 864 to 895 ft bgs, the final cuttings returned at 895 to 896 ft bgs are of a very fine felsic sand.

3.1.2 Groundwater

On the morning of November 12, 2008, regional groundwater was first detected in the R-39 borehole at 796 ft bgs. The borehole depth was 868 ft bgs. Before well construction, the Laboratory camera observed the water level in the open borehole at 824 ft bgs. After well construction, the water level was measured at 810 ft and 806 ft. Following overnight periods of resting during well development, the water level stabilized at approximately 826.5 ft bgs. Table 3.1-1 provides water levels measured during R-39 drilling, prewell construction, and well development.

4.0 WELL INSTALLATION

4.1 Well Design

The R-39 well was designed in accordance with the Consent Order and NMED approved the well design before installation (NMED 2007, 099257). LWSP used the results of the geophysical logging to design a 10-ft well screen from 860 to 870 ft bgs.

4.2 Well Construction

Well installation activities were started on November 19, 2008, and mostly completed by November 24, 2008. The Speedstar 50K rig was used for all well construction activities.

The R-39 well was constructed of 5.0-in.-inside diameter (I.D.)/5.563-in.-outside diameter (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 screen section was nominal 10.9 ft long with 10-ft length 5.0-in.-I.D. rod-based 0.020-in. wire-wrapped screen slots. The coupled unions between threaded sections were approximately 0.7 ft long. The casing and screen were factory-cleaned and steam-cleaned on-site before installation. A nominal 10-ft screened interval was chosen for R-39 with the top of the screen set at 859.03 ft bgs, approximately 1 ft above the target depth of 860 ft. A 6.5-ft stainless-steel sump was placed below the well screen.

The well was assembled from the bottom up and lowered into the borehole. The bottom of the sump landed on borehole slough material at 875.6 ft bgs. Figure 4.2-1 presents an as-built schematic showing construction details for the completed well.

After the well casing was assembled and lowered into the borehole, the process of installing annular backfill materials started. A 2.0-in.-I.D. steel tremie pipe was used to deliver the annular backfill materials under pressure; the materials were mixed with municipal water and pumped through the tremie pipe. To document that the annular materials settled to the proper position, the depth of the annular material was repeatedly measured and recorded. As the backfilling process progressed, the tremie pipe was withdrawn from the well. Once the backfill was installed to a depth above the regional groundwater (812 ft bgs), backfilling operations consisted of slowly pouring bentonite chips into the well annular space while the hydration water was pumped to depth. Above the bentonite seal (301 ft bgs), cement grout containing 5% bentonite gel was also pumped to depth as the tremie pipe was retracted. Figure 4.2-1 illustrates the types, depths, calculated volumes, and actual volumes of annular materials used in relation to the R-39 well screen.

On December 1, 2008, the stainless-steel well casing was cut to its final position. This established December 1, 2008, as the well completion date for R-39, as defined in Section IV.A.3.e.iv of the Consent Order.

5.0 WELL COMPLETION

5.1 Well Development

R-39 was developed by mechanical means, including swabbing, bailing, and pumping. Target water-quality parameters were turbidity <5 nephelometric turbidity units (NTUs), TOC <2 ppm, and other parameters stable.

Well development was conducted between December 1, 2008, and December 23, 2008. A Pullstar 1200K work-over rig was used for all well development activities. Initially, the sump was bailed using a bailer fitted with a mechanical suction device to remove silt and sand accumulated in the sump. Next, the screen was swabbed to disturb formation fines settled in the sand filter pack. The swabbing tool was a 5.0-in.-O.D. 1-in.-thick nylon disc attached to a steel rod, lowered by wireline, and drawn repeatedly across the screened interval. Then the bailer was used to remove groundwater until the recovered water was clear.

After swabbing and bailing, a 1.5-hp, 4-in.-O.D. Franklin Electric submersible pump was lowered into the well to continue well development. During well development pumping, water levels were measured to ensure that the pumping did not draw down the water column in the well and expose the pump. This also helped establish a preliminary flow rate of approximately 1.2 gpm. Also during well development pumping, groundwater was sampled and measured on-site for pH, SP, T, turbidity, DO, and salinity. The instrument used was a Horiba Water Quality Checker Model U-10. Once the turbidity dropped below 5 NTUs, additional groundwater samples were collected for TOC analysis. The field parameter measurements are tabulated in Table 5.1-1 and included in Appendix C.

Following the aquifer testing, several days of continued well development pumping were required to ensure the total purge volume was greater than the water volume introduced during drilling and well installation. From bailing and pumping, a total of 10,373 gal. of groundwater was purged from R-39 during well development and aquifer testing activities (Table 5.1-1). At the completion of well development, the turbidity was consistently measured at 1 NTU and TOC was not detected.

5.2 Aquifer Testing

On December 11, 2008, well development pumping was halted, and David Schafer and Associates began to prepare for aquifer testing. Details of the aquifer testing are presented in Appendix F.

An inflatable packer was positioned above a 5-hp Grundfos submersible pump and a nonvented In-Situ Level Troll 700 transducer was deployed into the well. The packer was used to minimize the effects of casing storage on the test data. On December 12, 2008, problems were encountered with system components but were repaired before short-duration pumping tests on December 13. A 24-h aquifer pumping test was conducted between December 14 and December 15, 2008. The transducer remained in the well collecting aquifer recovery data until it was removed on December 18, 2008. Results of the aquifer tests are described in Appendix F.

5.3 Dedicated Sampling System Installation

On February 19, 2009, a dedicated environmentally retrofitted 4-in.-O.D. Grundfos pump and a 2-hp Franklin Electric submersible motor were installed in R-39. The pump was deployed into the well on a type A304 grade stainless-steel 1.0-in.-I.D. discharge pipe. The pump intake was set at 858.78 ft bgs. Simultaneously, two 1.0-in.-I.D. flush threaded schedule 40 polyvinyl chloride pipes were installed as access tubes: one for a dedicated In-Situ Level Troll 500 transducer (vented), the other for manual water-level measurements. The capped access tubes were perforated from 854.7 to 855.5 ft bgs and positioned atop the pump. The pump discharge pipe and the transducer tubes rest on a 0.5-in. thick 6-in.-diameter stainless-steel landing plate positioned atop the stainless-steel well riser. Details of the dedicated sampling system installed in R-39 are presented in Figure 5.3-1.

5.4 Wellhead Completion

On January 27, 2009, a surface pad consisting of 4000-psi reinforced concrete, 10 ft × 10 ft × 6 in. thick, was installed at the R-39 well head. A 10-in.-I.D. steel protective casing with a locking lid was positioned over the stainless-steel well riser and cemented into the pad. In addition, four removable 4-in. steel bollards were installed around the pad. The pad and bollards will provide long-term structural integrity for the wellhead. A brass survey monument displaying the well name and elevation was embedded in the northwest corner of the pad. The concrete pad was slightly elevated above the ground surface and crowned to promote runoff.

The Laboratory mounted a permanent electric starter box with a connection for three-phase, 460-V portable generator power on the pad adjacent to the protective casing. The Laboratory connected the starter box and the power cable to the dedicated pump in the well. During site restoration, base course gravel was graded around the edges of the pad. Details of the wellhead completion are presented in Figures 4.2-1 and 5.3-1.

5.5 Geodetic Survey

Geodetic survey data for the center of the stainless-steel well casing landing plate, 10-in. protective casing, brass pin, and ground surface at R-39 were collected by Precision Surveying, Inc., on February 10, 2009. The survey data are presented in Table 5.4-1. Geodetic surveys were conducted using a Topcon Hiper plus global positioning system and Wild Heerbrugg NA1 level. The survey data were collected by a New Mexico 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.

5.6 Waste Management and Site Restoration

Wastes produced during drilling were managed in accordance with the “Waste Characterization Strategy Form or Drilling and Installation of Wells at TA-54 R-37, R-39, and R-40” (Document Catalog Number EP2008-0306). Wastes generated at the R-39 project include a small quantity of contact waste, drill cuttings, discharged drilling water, and purged groundwater. Following the completion of drilling, waste characterization samples were collected from cuttings and drilling water in the lined retention pit, and purged groundwater was sampled in an aboveground storage tank following well development. Final disposition of the wastes is ongoing.

If approved, liquid wastes may be land-applied in accordance with the NMED-approved Notice of Intent Decision Tree: Drilling, Development, Rehabilitation, and Sampling Purge Water. Drill cuttings may be land-applied pursuant to the Decision Tree of Management of Investigation-Derived Waste Solids from Drilling Operations.

Site restoration activities will include removing water and cuttings from the cuttings containment pit, removing the polyethylene liner, and backfilling and regrading the containment area. The berm installed between the drill pad and the established drainage channel will remain to protect the well head from erosion. The site will be reseeded with a Laboratory-approved seed mix, consisting of Indian rice grass, mountain broam, blue stem, sand drop, and slender wheat grass seed.

6.0 DEVIATIONS FROM PLANNED ACTIVITIES

In general, drilling, sampling, and well construction at R-39 were performed as specified in the "Drilling Work Plan for Regional and Intermediate Wells at Technical Area 54" (LANL 2007, 099662) and LANS subcontract 22851-009-08, Exhibit D, "Scope of Work and Technical Specifications—Drilling and Installation of Wells at TA-54."

The following changes to the original work plan were implemented after approval by LWSP.

- Drilling TD: Drilling at R-39 stopped at 896 ft bgs after advancing approximately 70 ft into the saturated portion of the regional aquifer. This was caused by the possibility of losing the open borehole due to geologic conditions. The planned TD for the R-39 borehole in the approved work plan (LANL 2007, 099662) was 965 ft bgs, or 150 ft below the regional aquifer piezometer surface estimated to be at 815 ft.
- During annular material backfilling activities, the sand pack surrounding the well screen was not mechanically surged. This was a field management decision. The actual volume of sand pack installed, compared with the volume calculated for a perfect 14.75-in. borehole, indicated that the borehole was not losing sand to the formation (Figure 4.2-1). If this had been the case, mechanical surging of the sand pack surrounding the screen would have been required to ensure a stable sand pack before installing annular materials higher in the well.

7.0 REFERENCES AND MAP DATA SOURCES

7.1 References

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

Copies of the master reference set are maintained at the NMED Hazardous Waste Bureau and the Directorate. The set was developed to ensure that the administrative authority has all material needed to review this document, and it is updated with every document submitted to the administrative authority. Documents previously submitted to the administrative authority are not included.

LANL (Los Alamos National Laboratory), October 2007. "Technical Area 54 Well Evaluation and Network Recommendations, Revision 1," Los Alamos National Laboratory document LA-UR-07-6436, Los Alamos, New Mexico. (LANL 2007, 098548)

LANL (Los Alamos National Laboratory), November 2007. "Drilling Work Plan for Regional and Intermediate Wells at Technical Area 54," Los Alamos National Laboratory document LA-UR-07-7578, Los Alamos, New Mexico. (LANL 2007, 099662)

NMED (New Mexico Environment Department), December 7, 2007. "Approval with Direction, Drilling Work Plan for Regional and Intermediate Wells at Technical Area 54," New Mexico Environment Department letter to D. Gregory (DOE-LASO) and D. McInroy (LANL) from J.P. Bearzi (NMED-HWB), Santa Fe, New Mexico. (NMED 2007, 099257)

7.2 Map Data Sources

Data sources used in original figures created for this report are described below and identified by legend title.

Data sources used in original figures created for this report are described below and identified by legend title (maps LRW09-01 and LRW09-02).

Dirt Road Arcs; Los Alamos National Laboratory, KSL Site Support Services, Planning, Locating and Mapping Section; 06 January 2004; as published 15 October 2008.

Groundwater Monitoring Locations; David Rogers, Los Alamos National Laboratory, Environmental Data & Analysis Group, GIS Project File PMR07007, unpublished data, April 2007.

Hypsography, 100-, 20- and 10-ft Contour Intervals; Los Alamos National Laboratory, ENV Environmental Remediation and Surveillance Program; 1991.

Locations for New Regional Aquifer Wells R-39 and R-40; Jon Marin, Los Alamos Technical Associates, Los Alamos, NM, June 2008.

Ownership Boundaries around LANL Area; Los Alamos National Laboratory, Site Planning & Project Initiation Group, Infrastructure Planning Division; 04 June 2008.

Paved Parking; Los Alamos National Laboratory, KSL Site Support Services, Planning, Locating and Mapping Section; 12 August 2002; as published 15 October 2008.

Paved Road Arcs; Los Alamos National Laboratory, KSL Site Support Services, Planning, Locating and Mapping Section; 06 January 2004; as published 15 October 2008.

Potential Release Sites; Los Alamos National Laboratory, Waste and Environmental Services Division, Environmental Data and Analysis Group, EP2008-0623; 1:2,500 Scale Data; 10 December 2008

Primary Landscape Features; Los Alamos National Laboratory, KSL Site Support Services, Planning, Locating and Mapping Section; 06 January 2004; as published 15 October 2008.

Road Centerlines; Los Alamos National Laboratory, KSL Site Support Services, Planning, Locating and Mapping Section; 15 December 2005; as published 15 October 2008.

Security and Industrial Fences and Gates; Los Alamos National Laboratory, KSL Site Support Services, Planning, Locating and Mapping Section; 06 January 2004; as published 15 October 2008.

Structures; Los Alamos National Laboratory, KSL Site Support Services, Planning, Locating and Mapping Section; 06 January 2004; as published 15 October 2008.

Technical Area Boundaries; Los Alamos National Laboratory, Site Planning & Project Initiation Group, Infrastructure Planning Division; 04 June 2008.

WQH Drainage_Arc; Los Alamos National Laboratory, ENV Water Quality and Hydrology Group; 1:24,000 Scale Data; 03 June 2003.

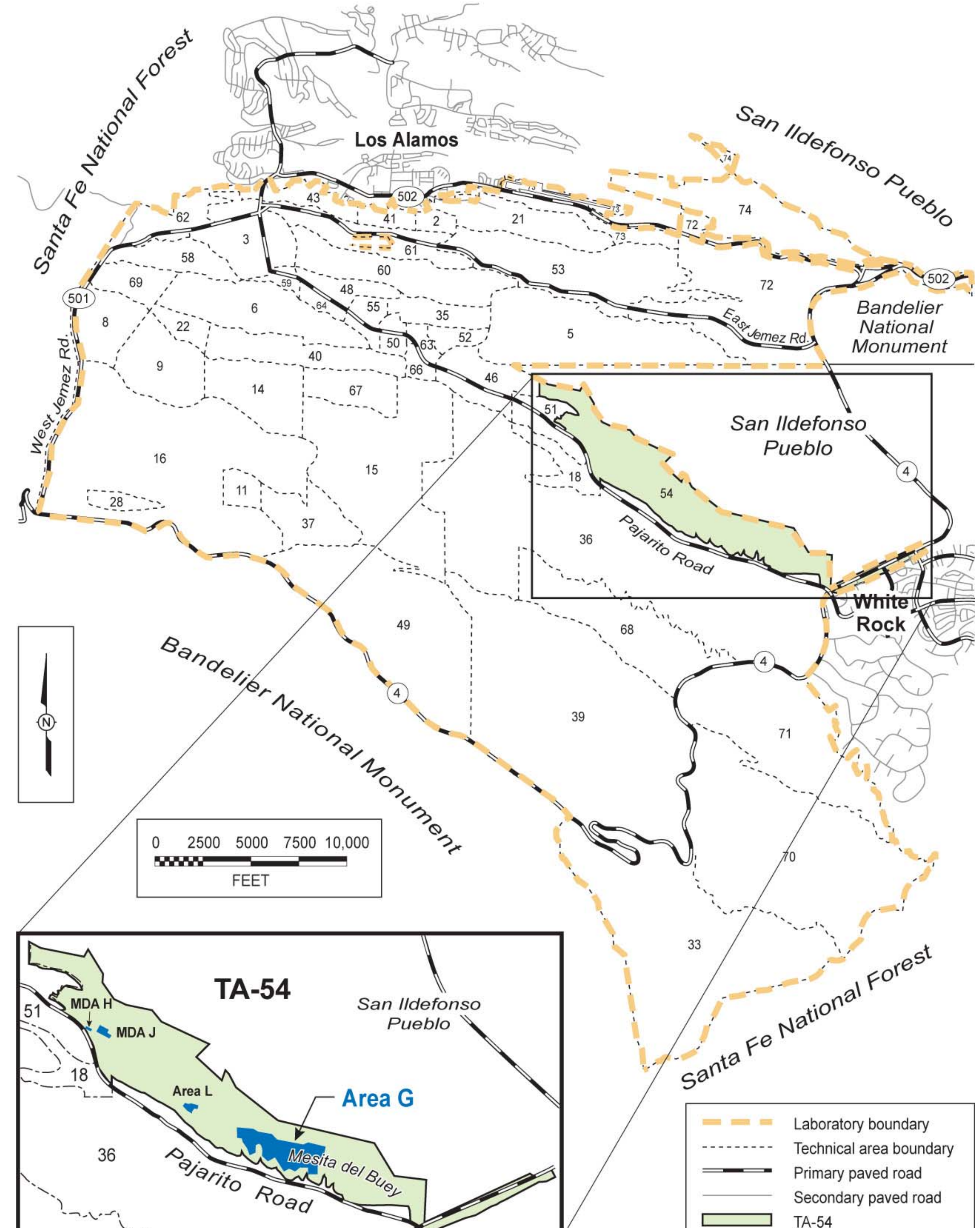

Figure 1.0-1 Area G in TA-54 with respect to Laboratory technical areas and surrounding land holdings

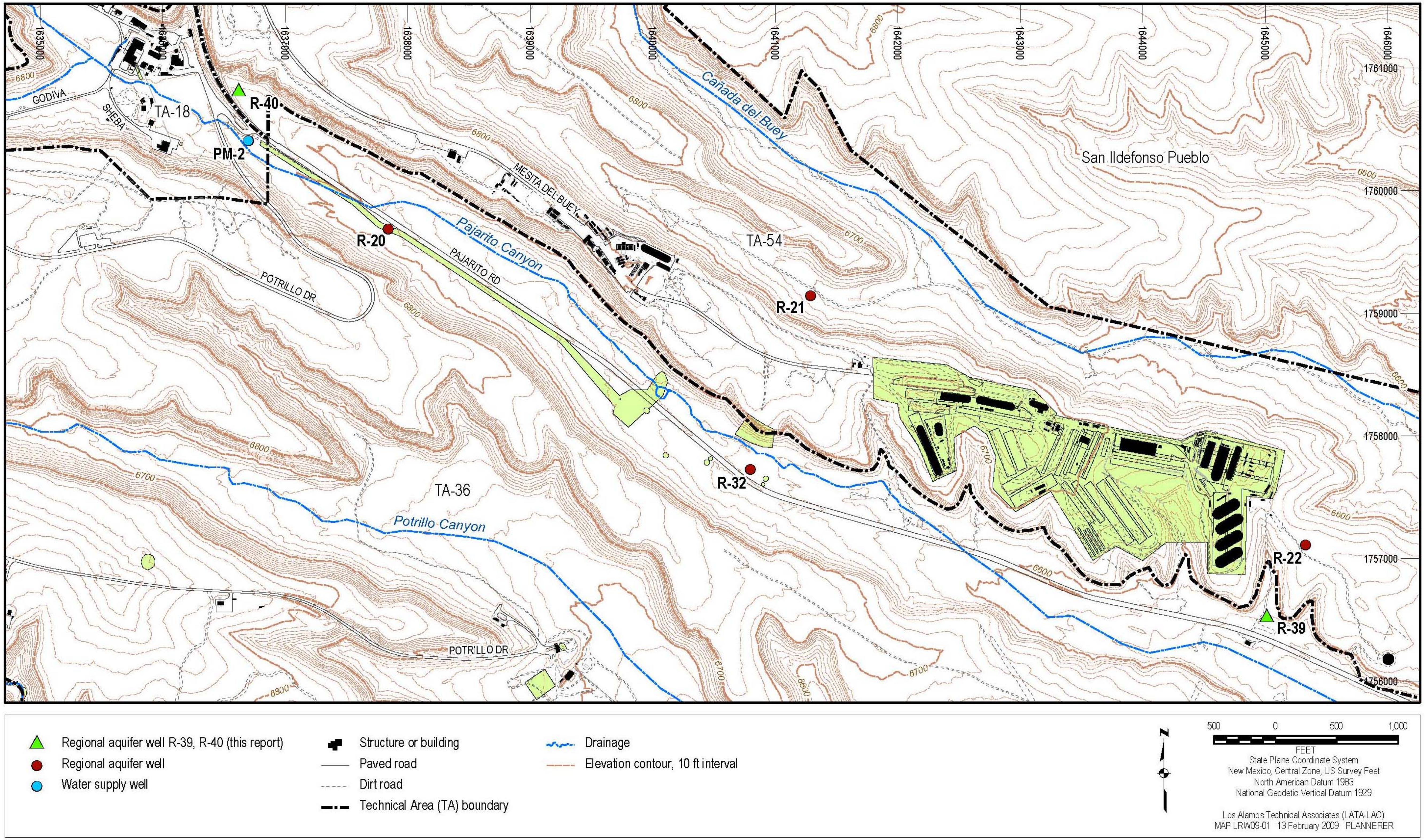

Figure 1.0-2 Regional aquifer wells R-39 and R-40

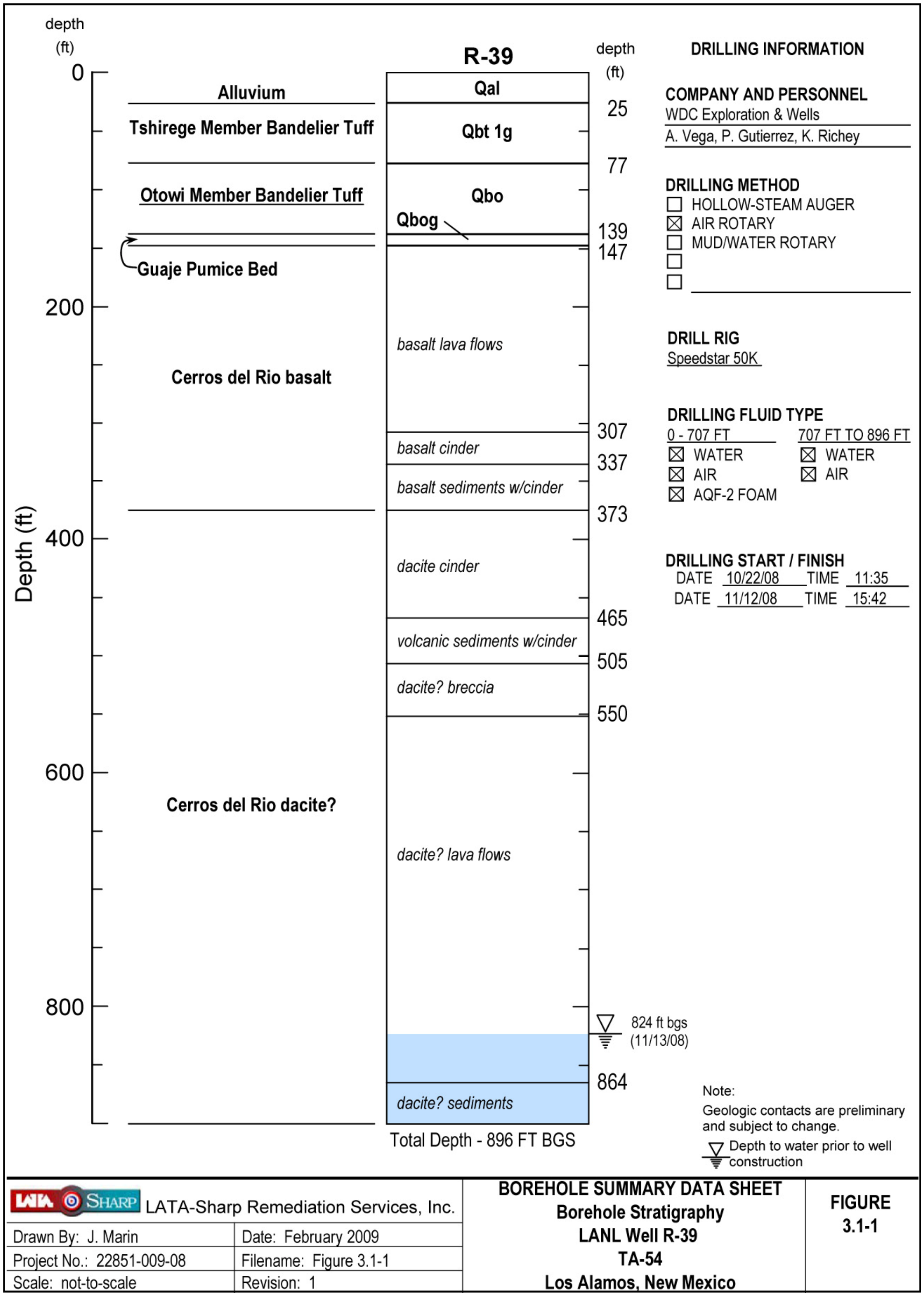

Figure 3.1-1 R-39 borehole stratigraphy

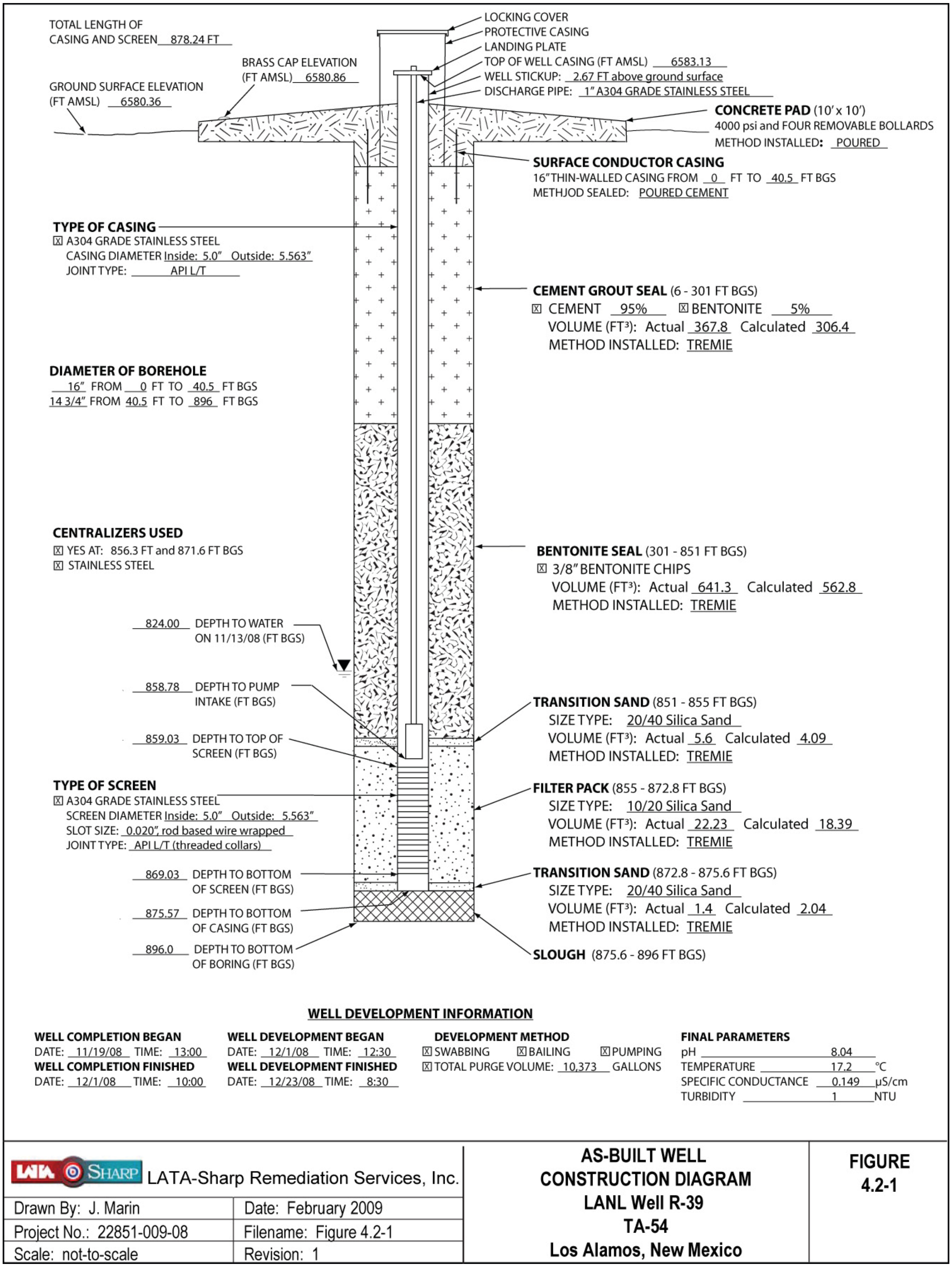

Figure 4.2-1 As-built well construction diagram well R-39, TA-54

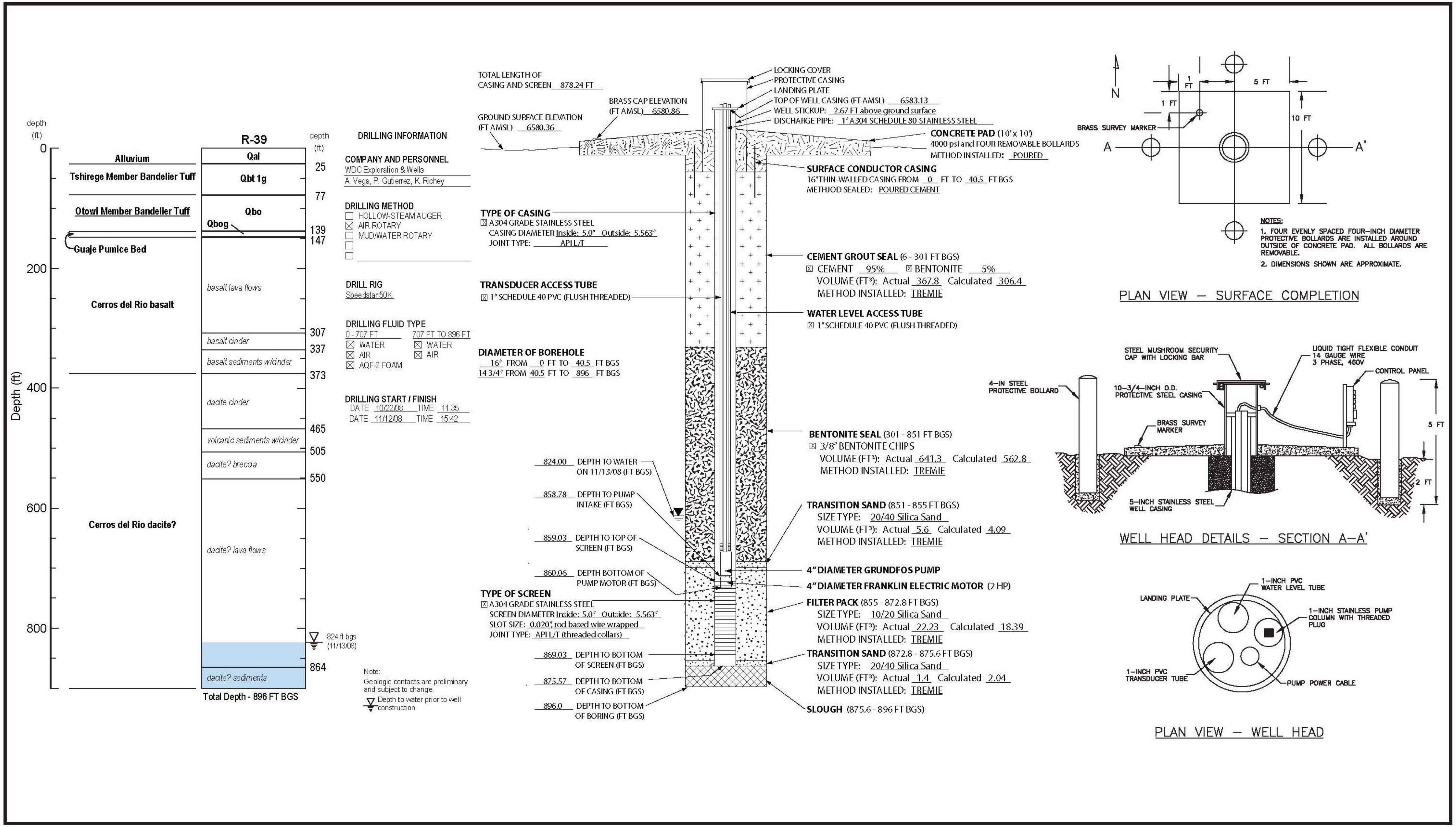

Figure 5.3-1 As-built completion schematic for regional aquifer well R-39

Table 2.2-1
Municipal Water and AQF-2 Foam
Used during Drilling and Well Construction at Well R-39

Date	Water (gal.)	Cumulative Water (gal.)	AQF-2 Foam (gal.)	Cumulative AQF-2 Foam (gal.)	Cumulative Returns in Pit (gal.)
Drilling					
10/22/08	0	0	0	0	0
10/23/08	0	0	0	0	0
10/24/08	400	400	10	10	300
10/25/08	3000	3400	20	30	2500
10/26/08	2000	5400	20	50	4000
10/27/08	0	5400	0	50	4000
10/28/08	0	5400	0	50	4000
10/29/08	2500	7900	20	70	5900
10/30/08	1500	9400	0	70	7000
11/04/08	0	9400	0	70	7000
11/05/08	0	9400	0	70	7000
11/06/08	1000	10400	4	74	7700
11/07/08	1000	11400	0	74	8400
11/08/08	1000	12400	0	74	9100
11/09/08	1500	13900	0	74	10200
11/10/08	2000	15900	0	74	11700
11/11/08	2000	17900	0	74	13200
11/12/08	0	17900	0	74	14700
Subtotal Drilling	**17900**	**17900**	**74**	**74**	**14700**
Well Construction					
11/13/08	0	17900	0	74	14700
11/20/08	1500	19400	0	74	14700
11/21/08	3000	22400	0	74	14700
11/22/08	1500	23900	0	74	14700
11/23/08	1000	24900	0	74	14700
Subtotal Well Construction	**7000**	**7000**	**0**	**0**	**0**
Total Volume (gal.)	**24900**	**24900**	**74**	**74**	**14700**

Table 2.3-1
Summary of Groundwater-Screening Samples Collected during Drilling, Well Development, and Aquifer Testing of Well R-39

Location ID	Sample ID	Date Collected	Collection Depth (ft bgs)	Sample Type
Drilling				
R-39	RC54-09-1035	11/12/08	868	Screening
Prewell Development				
R-39	RC54-09-1036	12/02/08	867.4	Screening
Well Development				
R-39	GW39-09-1585	12/03/08	865	TOC
R-39	GW39-09-1586	12/03/08	865	TOC
R-39	GW39-09-1587	12/07/08	865	TOC
R-39	GW39-09-1588	12/07/08	865	TOC
R-39	GW39-09-1589	12/08/08	865	TOC
R-39	GW39-09-1590	12/08/08	865	TOC
R-39	GW39-09-1591	12/09/08	865	TOC
R-39	GW39-09-1608	12/10/08	865	TOC
Aquifer Test				
R-39	GW39-09-1593	12/14/08	850	TOC
R-39	GW39-09-1594	12/15/08	850	TOC
Postaquifer Test				
R-39	GW39-09-1595	12/19/08	850	TOC
R-39	GW39-09-1596	12/20/08	850	TOC
R-39	GW39-09-1597	12/21/08	850	TOC
Postwell Development				
R-39		2/19/09	858.78	Full Suite

Table 2.4-1
R-39 Video and Geophysical Logging Runs

Date	Depth (ft bgs)	Description
11/05/2008	685	LANL ran video camera to search for possible perched groundwater.
11/13/2008	896	Schlumberger ran a suite Accelerator Porosity Sonde (neutron porosity), array induction, combined magnetic resonance, natural and spectral gamma, Elemental Capture Sonde, and Formation Micro-Imager in the open borehole to TD at 896 ft. LANL ran video camera to search for possible perched groundwater.

Table 3.1-1
Summary of Water-Level Measurements at Well R-39

Date	Time	DTW (ft bgs)	Source	Type	After
Drilling					
11/04/08	9:30	642.5	DTW Meter	Drilling water	Drilling
11/04/08	16:20	640	DTW Meter	Drilling water	Drilling
11/04/08	16:58	648.5	DTW Meter	Drilling water	Drilling
11/05/08	9:15	665	DTW Meter	Drilling water	Drilling
11/12/08	9:30	796	DTW Meter	Groundwater	Drilling
11/12/08	11:00	806	DTW Meter	Groundwater	Drilling
11/12/08	11:20	806	DTW Meter	Groundwater	Drilling
11/12/08	11:40	806	DTW Meter	Groundwater	Drilling
11/12/08	12:00	806	DTW Meter	Groundwater	Drilling
11/13/08	9:06	824	LANL camera	Groundwater	TD
Postwell Construction					
12/01/08	12:45	830	DTW Meter	Groundwater	Well Construction
12/02/08	9:00	825.51	DTW Meter	Groundwater	Annular fill
Well Development					
12/03/08	14:15	841.75	DTW Meter	Groundwater	Pumping
12/03/08	15:15	844.88	DTW Meter	Groundwater	Pumping
12/03/08	16:45	846.55	DTW Meter	Groundwater	Pumping
12/04/08	7:08	837.17	DTW Meter	Groundwater	Resting
12/05/08	9:30	826.23	DTW Meter	Groundwater	Resting
12/05/08	15:00	826.81	DTW Meter	Groundwater	Resting
12/05/08	15:30	837.33	DTW Meter	Groundwater	Pumping
12/05/08	15:38	830.83	DTW Meter	Groundwater	Resting
12/05/08	15:40	837.33	DTW Meter	Groundwater	Pumping
12/05/08	16:04	827.13	DTW Meter	Groundwater	Resting
12/05/08	16:10	837.33	DTW Meter	Groundwater	Pumping
12/05/08	16:30	827.24	DTW Meter	Groundwater	Resting
12/05/08	16:37	838.03	DTW Meter	Groundwater	Pumping
12/06/08	12:07	834.43	DTW Meter	Groundwater	Resting
12/06/08	13:51	843.63	DTW Meter	Groundwater	Pumping
12/06/08	16:25	842.43	DTW Meter	Groundwater	Pumping
12/06/08	17:00	842.53	DTW Meter	Groundwater	Pumping
12/07/08	7:19	826.33	DTW Meter	Groundwater	Resting
12/07/08	8:30	842.63	DTW Meter	Groundwater	Pumping
12/07/08	9:00	843.33	DTW Meter	Groundwater	Pumping
12/07/08	9:48	843.85	DTW Meter	Groundwater	Pumping

Table 3.1-1 (continued)

Date	Time	Depth to Water (ft bgs)	Source	Type	After
12/07/08	11:32	845.03	DTW Meter	Groundwater	Pumping
12/07/08	15:28	844.53	DTW Meter	Groundwater	Pumping
12/07/08	16:32	844.33	DTW Meter	Groundwater	Pumping
12/08/08	7:08	826.48	DTW Meter	Groundwater	Resting
12/08/08	7:48	844.33	DTW Meter	Groundwater	Pumping
12/08/08	8:45	845.28	DTW Meter	Groundwater	Pumping
12/08/08	11:07	845.68	DTW Meter	Groundwater	Pumping
12/08/08	13:13	845.68	DTW Meter	Groundwater	Pumping
12/09/08	7:44	826.85	DTW Meter	Groundwater	Resting
12/09/08	9:30	856.31	DTW Meter	Groundwater	Pumping
12/09/08	10:05	863.11	DTW Meter	Groundwater	Pumping
12/09/08	10:35	841.4	DTW Meter	Groundwater	Pumping
12/09/08	11:05	845.46	DTW Meter	Groundwater	Pumping
12/09/08	11:35	845.55	DTW Meter	Groundwater	Pumping
12/09/08	12:05	846.31	DTW Meter	Groundwater	Pumping
12/09/08	12:35	847.64	DTW Meter	Groundwater	Pumping
12/09/08	13:05	847.31	DTW Meter	Groundwater	Pumping
12/09/08	13:35	847.98	DTW Meter	Groundwater	Pumping
12/09/08	14:05	848.88	DTW Meter	Groundwater	Pumping
12/09/08	14:35	842.64	DTW Meter	Groundwater	Pumping
12/09/08	15:05	848.81	DTW Meter	Groundwater	Pumping
12/09/08	15:35	843.22	DTW Meter	Groundwater	Pumping
12/09/08	16:05	848.13	DTW Meter	Groundwater	Pumping
12/09/08	16:35	849.29	DTW Meter	Groundwater	Pumping
12/09/08	16:40	847.31	DTW Meter	Groundwater	Pumping

Note: Rows shaded in gray indicate that after overnight periods of resting during well development, the water level stabilized at approximately 826.5 ft bgs.

Table 5.1-1
Well Development and Aquifer Test Volumes and
Field Water-Quality Parameter Measurements at Well R-39

Date	Time	pH	SP (µS/cm)[a]	T (°C)	Turbidity (NTU)	DO (mg/L)	Salinity %	TOC Result (ppm)	Comment	End-of-Day Cumulative Purge Volume (gal.)
Well Development										
12/1/08	16:20	—[b]	—	—	—	—	—	—	Bailing	205
12/2/08	9:00	4	4.55	9	0	14	0.22	—	Calibrate Horiba	—
12/2/08	9:06	7.78	0.253	16	81	9.32	0.01	—	Bailing	205
12/3/08	8:45	8.19	0.236	14.6	43	9.6	0	—	Pumping	—
12/3/08	9:15	8.19	0.216	15.8	69	7.69	0	—	Pumping	—
12/3/08	9:30	8.62	0.194*	14.5	48	3.15	0	—	Pumping	—
12/3/08	9:45	8.57	0.188	16.2	22	3.89	0	—	Pumping	—
12/3/08	10:00	8.43	0.182	16.3	16	3.5	0	—	Pumping	—
12/3/08	10:15	8.41	0.18/2	20.3	10	3.63	0	—	Pumping	—
12/3/08	10:30	8.51	0.182	20.8	10	3.15	0	—	Pumping	—
12/3/08	10:45	8.42	0.175	17.7	8	3.46	0	—	Pumping	—
12/3/08	11:00	8.44	0.174	16.6	6	3.2	0	—	Pumping	—
12/3/08	11:15	8.43	0.174	20.6	6	4.3	0	—	Pumping	—
12/3/08	11:30	9.45	0.174	20.5	6	3.03	0	—	Pumping	—
12/3/08	11:45	8.15	0.174	21	5	2.68	0	—	Pumping	—
12/3/08	12:00	8.39	0.17	21.2	4	2.58	0	—	Pumping	—
12/3/08	12:15	8.36	0.169	20.7	4	2.9	0	3.8/3.29	Pumping	—
12/3/08	12:30	8.03	0.172	21	4	3.32	0	—	Pumping	—
12/3/08	12:45	8.01	0.169	21.2	4	3.51	0	—	Pumping	—
12/3/08	13:00	8.07	0.166	21.7	6	3.93	0	—	Pumping	—
12/3/08	13:15	8.21	0.163	21.9	6	3.07	0	—	Pumping	—
12/3/08	13:30	8.38	0.163	22	4	3.06	0	—	Pumping	—
12/3/08	13:45	8.07	0.163	21.8	3	3.04	0	—	Pumping	—
12/3/08	14:00	8.19	0.162	22	3	3.27	0	—	Pumping	—
12/3/08	14:15	8.08	0.162	22.2	4	3.52	0	—	Pumping	—
12/3/08	14:30	8.13	0.161	22.4	4	3.59	0	—	Pumping	—
12/3/08	14:45	8.13	0.164	21.4	5	3.77	0	—	Pumping	—
12/3/08	15:00	8.12	0.162	22.3	3	3.42	0	—	Pumping	—
12/3/08	15:15	7.91	0.162	22.1	5	3.53	0	—	Pumping	—
12/3/08	15:30	8.12	0.16	22	4	3.62	0	—	Pumping	—
12/3/08	15:45	8.17	0.159	21.1	5	3.69	0	—	Pumping	—
12/3/08	16:00	8.08	0.159	21.9	4	3.54	0	—	Pumping	—

Table 5.1-1 (continued)

Date	Time	pH	SP (µS/cm)	T (ºC)	Turbidity (NTU)	DO (mg/L)	Salinity %	TOC Result (ppm)	Comment	End-of-Day Cumulative Purge Volume (gal.)
12/3/08	16:15	8.13	0.16	21.9	3	3.71	0	—	Pumping	—
12/3/08	16:30	8.07	0.159	21.7	2	4.23	0	—	—	—
12/3/08	16:45	8.02	0.157	19.1	2	4.23	0	2.27/2.03	—	—
12/3/08	17:00	7.79	0.158	21	2	3.72	0	—	Pumping	906
12/4/08	7:30	7.59	0.181	13.2	25	2.82	0	—	Pumping	—
12/4/08	8:00	8.11	0.174	18.1	10	2.17	0	—	Pumping	—
12/4/08	8:30	8.0	0.165	18.8	10	3.62	0	—	Pumping	—
12/4/08	9:15	3.98	4.66	3.4	0	15.6	0.22	—	Calibrate Horiba	—
12/4/08	9:30	7.3	0.175	19.6	8	3.87	0	—	Pumping	—
12/4/08	10:00	8.11	0.196	19	13	3.94	0	—	Pumping	1153
12/5/08	9:11	3.93	4.77	9.7	1	10.3	0.24	—	Calibrate Horiba	—
12/5/08	13:09	4	4.97	25.3	0	7.95	0	—	Calibrate Horiba	—
12/5/08	16:37	—	—	—	—	—	—	—	Try larger pump	1193
12/6/08	12:05	4	4.47	20	0	9.66	0.23	—	Calibrate Horiba	—
12/6/08	12:13	6.88	0.193	16.3	8	9.64	0	—	Pumping	—
12/6/08	12:30	7.75	0.19	19.3	8	—	0	—	Pumping	—
12/6/08	12:45	7.42	0.192	19.4	10	—	0	—	Pumping	—
12/6/08	13:50	7.61	.017	20.5	2	3.11	0	—	Pumping	—
12/6/08	14:00	7.29	0.169	21.1	1	6.39	0	—	Pumping	—
12/6/08	14:15	7.59	0.167	21.6	1	2.66	0	—	Pumping	—
12/6/08	14:30	7.76	0.166	219	2	2.66	0	—	Pumping	—
12/6/08	14:45	—	0.165	21.1	5	—	0	—	Pumping	—
12/6/08	15:00	7.25	0.165	21.4	1	3.28	0	—	Pumping	—
12/6/08	15:15	7.68	0.165	21.5	0	3.41	0	—	Pumping	—
12/6/08	15:30	7.82	0.163	21.9	0	2.82	0	—	Pumping	—
12/6/08	15:45	7.64	0.163	21.5	0	3.41	0	—	Pumping	—
12/6/08	16:00	7.41	0.162	21.4	0	2.86	0	—	Pumping	—
12/6/08	16:15	7.65	0.162	21.4	0	2.95	0	—	Pumping	—
12/6/08	16:30	7.72	0.162	20.3	0	3.24	0	—	Pumping	—
12/6/08	16:45	7.56	0.162	21.1	0	3.18	0	—	Pumping	—
12/6/08	17:00	7.59	0.162	21.4	0	3.04	0	—	Pumping	1579
12/7/08	7:15	4	4.48	17.5	0	9.79	0.23	—	Calibrate Horiba	—

Table 5.1-1 (continued)

Date	Time	pH	SP (µS/cm)	T (ºC)	Turbidity (NTU)	DO (mg/L)	Salinity %	TOC Result (ppm)	Comment	End-of-Day Cumulative Purge Volume (gal.)
12/7/08	7:30	6.59	0.186	17.3	2	8.58	0	31.1/29.4	Pumping	—
12/7/08	11:30	6.84	0.16	21.5	6	—	0	—	Pumping	—
12/7/08	11:50	7.21	0.16	21.1	10	8.24	0	—	Pumping	—
12/7/08	15:30	7.41	0.157	21.5	2	4.34	0	—	Pumping	—
12/7/08	16:33	7.54	0.159	21.6	1	5.29	0	—	Pumping	—
12/7/08	16:45	7.49	0.159	21.9	1	5.38	0	—	Pumping	—
12/7/08	17:00	7.59	0.162	21.4	0	5.12	0	1.16/2.59	Pumping	2573
12/8/08	7:20	6.83	0.158	16.4	2	3.97	0	—	Pumping	—
12/8/08	8:45	7.67	0.164	20.5	8	3.28	0	0.92/0.82	Pumping	—
12/8/08	9:30	7.8	0.163	21.1	5	—	0	—	Pumping	—
12/8/08	11:07	7.5	0.162	21.3	3	4.52	0	—	Pumping	—
12/8/08	15:10	7.82	0.16	20.4	3	4.86	0	—	Pumping	—
12/8/08	16:00	7.84	0.159	21.2	3	4.35	0	—	Pumping	—
12/8/08	17:00	—	—	—	—	—	—	1.16/0.85	Pumping	3643
12/9/08	8:00	4.03	4.48	18.2	0	9.34	0.23	—	Calibrate Horiba	—
12/9/08	8:15	—	0.158	18.1	4	—	0	—	Pumping	—
12/9/08	8:35	7.31	0.158	18.9	12	3.52	0	—	Pumping	—
12/9/08	9:00	8.06	0.153	19	18	4.1	0	—	Pumping	—
12/9/08	9:30	8.1	0.151	19	5	4.93	0	—	Pumping	—
12/9/08	10:05	8.1	0.151	19.6	14	4.76	0	—	Pumping	—
12/9/08	10:35	7.43	0.143	20.5	6	4.77	0	—	Pumping	—
12/9/08	11:05	7.29	0.142	20	5	5.01	0	—	Pumping	—
12/9/08	11:35	7.45	0.144	20.9	6	4.57	0	—	Pumping	—
12/9/08	12:05	7.94	0.15	20.9	5	4.58	0	—	Pumping	—
12/9/08	12:35	8.1	0.149	21.2	4	4.27	0	—	Pumping	—
12/9/08	13:05	8.05	0.149	21.6	2	4.08	0	0.54/0.56	Pumping	—
12/9/08	13:35	8.13	0.149	20.7	5	4.66	0	—	Pumping	—
12/9/08	14:05	7.95	0.149	21.1	3	4.53	0	—	Pumping	—
12/9/08	14:35	7.86	0.149	20.6	5	4.29	0	—	Pumping	—
12/9/08	15:05	7.62	0.15	20.4	1	4.31	0	—	Pumping	—
12/9/08	15:35	7.63	0.149	20.2	2	4.33	0	—	Pumping	—
12/9/08	16:05	8.07	0.15	21	2	4.37	0	—	Pumping	—
12/9/08	16:35	8.16	0.149	21	1	4.51	0	—	Pumping	—
12/9/08	16:40	8.17	0.149	21.1	1	4.53	0	—	Pumping	—
12/9/08	17:00	—	—	—	—	—	—	—	Pumping	—

Table 5.1-1 (continued)

Date	Time	pH	SP (µS/cm)	T (ºC)	Turbidity (NTU)	DO (mg/L)	Salinity %	TOC Result (ppm)	Comment	End-of-Day Cumulative Purge Volume (gal.)
Preaquifer Test										
12/10/08	16:20	6.09	0.17	17.8	10	3.91	0	—	Pumping	—
12/10/08	19:50	—	—	—	—	—	—	0.55/0.84	Pumping	—
12/10/08	20:00	—	—	—	—	—	—	—	Pumping	4864
12/12/08	7:18	3.97	4.46	15.2	1	7.66	0.22	—	Calibrate Horiba	—
12/12/08	7:40	4	4.45	15	0	8.48	0.22	—	Calibrate Horiba	—
12/12/08	9:14	7.04	0.176	15.8	80	1.26	0	—	Pumping	4917
12/13/08	—	—	—	—	—	—	—	—	Pumping	5016
Aquifer Test (24 h)										
12/14/08	6:30	3.99	4.5	8.3	0	10.3	0.22	—	Calibrate Horiba	—
12/14/08	7:00	—	—	—	—	—	—	—	Pumping	—
12/14/08	7:05	5.93	0.218	15.2	8	4.0	0	—	Pumping	—
12/14/08	7:30	7.28	0.163	15.4	9	2.99	0	—	Pumping	—
12/14/08	8:15	7.85	0.156	20.2	10	3.17	0	—	Pumping	—
12/14/08	9:00	7.85	0.154	21	7	4.06	0	—	Pumping	—
12/14/08	10:00	7.81	0.153	20.8	5	3.73	0	—	Pumping	—
12/14/08	11:00	7.9	0.151	21.6	4	3.91	0	0.53/0.33	Pumping	—
12/14/08	12:05	7.87	0.151	21	3	4.35	0	—	Pumping	—
12/14/08	13:00	7.98	0.151	20.9	3	3.59	0	—	Pumping	—
12/14/08	14:00	7.8	0.147	21.1	3	4.23	0	—	Pumping	—
12/14/08	15:20	7.98	0.125	21.4	3	4.43	0	—	Pumping	—
12/14/08	16:00	7.78	0.15	21.5	3	4.06	0	—	Pumping	—
12/14/08	17:00	7.8	0.15	21	3	4.52	0	—	Pumping	—
12/14/08	18:15	7.62	0.15	22	3	4.56	0	—	Pumping	—
12/14/08	19:24	7.9	0.151	22	2	5.16	0	—	Pumping	—
12/14/08	20:00	7.84	0.15	23.3	3	5.06	0	—	Pumping	—
12/14/08	21:00	7.92	0.15	23.3	2	4.52	0	—	Pumping	—
12/14/08	22:00	7.94	0.15	23.2	3	4.85	0	—	Pumping	—
12/14/08	23:00	7.97	0.151	22.4	2	4.5	0	—	Pumping	—
12/15/08	0:00	7.91	0.15	22.4	3	0.85	0	—	Pumping	—
12/15/08	1:00	7.96	0.15	23	3	4.21	0	—	Pumping	—
12/15/08	2:00	8.01	0.149	23	3	4.46	0	—	Pumping	—
12/15/08	3:00	7.99	0.149	22.9	2	4.27	0	—	Pumping	—
12/15/08	4:00	8.03	0.1498	22.4	3	3.86	0	—	Pumping	—

Table 5.1-1 (continued)

Date	Time	pH	SP (µS/cm)	T (ºC)	Turbidity (NTU)	DO (mg/L)	Salinity %	TOC Result (ppm)	Comment	End-of-Day Cumulative Purge Volume (gal.)
12/15/08	5:00	8.0	0.149	23	3	4.15	0	—	Pumping	—
12/15/08	6:00	7.95	0.149	23.3	3	3.87	0	—	Pumping	—
12/15/08	7:00	7.99	0.149	22.9	2	4.35	0	ND/ND	Pumping	7490
Postaquifer Test Well Development										
12/19/08	11:07	4.17	4.64	13.3	2	7.49	0.23	—	Calibrate Horiba	—
12/19/08	11:39	5.25	0.243	12.4	11	1.28	0	—	Pumping	—
12/19/08	12:02	7.56	0.165	17.9	13	1.92	0	—	Pumping	—
12/19/08	13:00	7.8	0.154	20.3	3	3.34	0	—	Pumping	—
12/19/08	13:57	7.52	0.153	20.2	1	3.74	0	—	Pumping	—
12/19/08	15:00	7.88	0.152	20.8	1	3.99	0	—	Pumping	—
12/19/08	16:15	7.38	0.151	21	1	3.99	0	—	Pumping	—
12/19/08	17:00	7.37	0.15	19.4	1	3.93	0	ND/ND	Pumping	—
12/19/08	17:02	7.33	0.15	21.1	1	3.98	0	—	Pumping	7921
12/20/08	7:12	7.58	0.15	15.3	1	3.93	0	—	Pumping	—
12/20/08	9:46	7.29	0.152	21.1	3	4.05	0	—	Pumping	—
12/20/08	13:35	7.02	.148	21	1	4.3	0	—	Pumping	—
12/20/08	15:24	8.02	0.151	21	1	3.72	0	—	Pumping	—
12/20/08	16:45	8.03	0.153	21.5	1	3.99	0	ND/ND	Pumping	—
12/20/08	17:00	7.97	0.15	21.2	1	3.94	0	—	Pumping	8698
12/21/08	7:05	7.84	0.155	15.8	1	3.21	0	—	Pumping	—
12/21/08	9:28	7.24	0.153	19.2	3	3.54	0	—	Pumping	—
12/21/08	11:20	7.87	0.149	21.3	1	3.92	0	—	Pumping	—
12/21/08	14:10	7.49	0.15	19.6	1	3.99	0	—	Pumping	—
12/21/08	16:45	7.57	0.15	20.9	1	3.93	0	—	Pumping	—
12/21/08	17:00	8.0	0.149	21.4	1	3.78	0	ND/ND	Pumping	9487
12/22/08	7:00	8.01	0.151	15.7	1	3.19	0	—	Pumping	—
12/22/08	7:40	7.89	0.155	16.3	2	3.32	0	—	Pumping	—
12/22/08	10:17	7.3	0.15	20.2	1	3.74	0	—	Pumping	—
12/22/08	11:10	7.86	0.15	20.4	1	3.57	0	—	Pumping	—
12/22/08	15:30	7.26	0.15	20.1	1	3.73	0	—	Pumping	—
12/22/08	16:15	7.57	0.149	20.5	1	3.83	0	—	Pumping	—
12/22/08	16:45	7.89	0.149	20.4	1	3.82	0	—	Pumping	—
12/22/08	17:00	8.04	0.149	17.2	1	3.7	0	—	Pumping	10273
12/23/08	8:30	—	—	—	—	—	—	—	Pumping	10373

[a] µS/cm = Microsiemens per centimenter.

[b] — = Analysis not conducted.

Table 5.4-1
R-39 Survey Coordinates

Northing	Easting	Elevation	Identification
1756488.997	1644995.985	6580.86	R-39 brass monument in cement pad
1756490.497	1644994.485	6582.63	R-39 ground surface adjacent to pad
1756484.768	1644999.792	6583.79	R-39 top of 10-in protective casing
1756484.768	1644999.792	6583.13	R-39 top of stainless-steel well casing

Appendix A

Acronyms and Abbreviations,
Metric Conversion Table, and Data Qualifier Definitions

A-1.0 ACRONYMS ABBREVIATIONS

µS/cm	microsiemens per centimeter
AIT	Array Induction Tool
amsl	above mean sea level
APS	Accelerator Porosity Sonde
ASTM	American Society for Testing and Materials
bgs	below ground surface
CMR	Combinable Magnetic Resonance
Consent Order	Compliance Order on Consent
cu	capture unit
DO	dissolved oxygen
DTW	depth to water
EES-14	Earth and Environmental Science Division–Hydrology, Geochemistry, and Geology Group
ENV-MAQ	Environmental Division–Meteorology and Air Quality Group
ER/RRES-WQH	Environmental Restoration/Risk Reduction and Environmental Stewardship/Water Quality and Hydrology
FMI	Formation Micro-Imager
gAFI	American Petroleum Institute gamma ray
GR	gamma ray
HNGS	Hostile Natural Gamma Spectroscopy
lbf	pound force
IC	ion chromatography
ICPMS	inductively coupled (argon) plasma mass spectrometry
ICPOES	inductively coupled (argon) plasma optical emission spectroscopy
I.D.	inside diameter
K	hydraulic conductivity
LANL	Los Alamos National Laboratory
LANS	Los Alamos National Security

LSRS	Los Alamos Technical Associates, Inc.–Sharp Remediation Services, Inc.
LWSP	LANL Water Stewardship Program
MCFL	Micro-Cylindrically Focused Log
MDA	material disposal area
ms	millisecond
NMED	New Mexico Environment Department
NTU	nephelometric turbidity unit
O.D.	outside diameter
ohm-m	ohmmeter
QA	quality assurance
QC	quality control
RCRA	Resource Conservation and Recovery Act
RPF	Records Processing Facility
SP	specific conductivity
T	temperature
TA	technical area
TD	total depth
TDS	total dissolved solids
TOC	total organic carbon
VOC	volatile organic compound
WDC	Water Development Company Exploration & Wells

A-2.0 METRIC CONVERSION TABLE

Multiply SI (Metric) Unit	by	To Obtain U.S. Customary Unit
kilometers (km)	0.62137	miles (mi)
kilometers (km)	3281	feet (ft)
meters (m)	3.2808	feet (ft)
meters (m)	39.3701	inches (in.)
centimeters (cm)	0.03281	feet (ft)
centimeters (cm)	0.3937	inches (in.)
millimeters (mm)	0.0394	inches (in.)
micrometers or microns (µm)	0.00004	inches (in.)
square kilometers (km^2)	0.3861	square miles (mi^2)
hectares (ha)	2.4710	acres
square meters (m^2)	10.7639	square feet (ft^2)
cubic meters (m^3)	35.31	cubic feet (ft^3)
kilograms (kg)	2.2046	pounds (lb)
grams (g)	0.0353	ounces (oz)
grams per cubic centimeter (g/cm^3)	62.422	pounds per cubic foot (lb/ft^3)
milligrams per kilogram (mg/kg)	1	parts per million (ppm)
micrograms per gram (µg/g)	1	parts per million (ppm)
liters (L)	0.26471	gallons (gal.)
milligrams per liter (mg/L)	1	parts per million (ppm)
degrees Celsius (°C)	9/5 + 32	degrees Fahrenheit (°F)

A-3.0 DATA QUALIFIER DEFINITIONS

Data Qualifier	Definition
U	The analyte was analyzed for but not detected.
J	The analyte was positively identified, and the associated numerical value is estimated to be more uncertain than would normally be expected for that analysis.
J+	The analyte was positively identified, and the result is likely to be biased high.
J-	The analyte was positively identified, and the result is likely to be biased low.
UJ	The analyte was not positively identified in the sample, and the associated value is an estimate of the sample-specific detection or quantitation limit.
R	The data are rejected as a result of major problems with quality assurance/quality control (QA/QC) parameters.

Appendix B

Well R-39 Lithologic Log

LATA-Sharp Remediation Services, Inc.
Borehole Log

Project: LWSP Regional Aquifer Wells **Page 1 of 9**

Borehole Location ID: R-39
Date: October 22 to November 12, 2008
TA- 54
Attitude: Vertical
AOC/SWMU: NA
Drill Operator: Alberto Vega
Drilling Company: WDC Exploration and Wells
Depth to Perched Saturation (ft): NA
Drilling equipment: Speedstar 50K
Depth to Regional Saturation (ft): 824 ft
Geologist: Jon Marin
Total Depth (ft): 896 ft
Sampling equipment: Cuttings-grab; water-airlift, bail, and pump

Depth (ft)	Radiological Screening	Surface Casing	Open Borehole	Cuttings Sample	Graphic Log	Lithology	Notes	Well Construction	Annular Backfill Material
0		16 inch thin walled steel casing (0–40)				(0.0, 25.0) Qal: Alluvium, dark reddish brown sand, silt , and clay, organic at top, with some indurated tuff fragments and dacite pebbles and cobbles.	Regional aquifer well R-39 is located approximately 500 ft southeast from the southeastern boundary corner of MDA G and 100 ft north of Pajarito Road in TA-54. The 16" surface casing was cemented in place.		Concrt.
5									Neat Cement
10									
15									
20									
25						(25.0, 77.0) Qbt1g: Pinkish gray 5YR6/2 vitric ash flow tuff; vitric pumice fragments have well defined tube structures, phenocrysts are quartz and sanidine, lithics are mostly dacite, slightly magnetic from minute magnetite crystals.			
30									
35									
40			Open Borehole						
45	NDA			chips					
50	NDA			chips					
55	NDA			chips					
60	NDA			chips					
65	NDA			chips			Increase in vitric pumice lapilli suggests air-fall Tsankawi Pumice Bed from 75 ft to 77 ft at base of unit 1g.		
70	NDA			chips					
75	NDA			chips					
80	NDA			chips		(77.0, 139.0) Qbo: Pinkish gray 5YR7/2 vitric ash flow	From 77 ft to 95 ft, possible Cerro Toledo		

bgs = below ground surface; Concrt. = concrete; DTW = Depth to Water (ft bgs); FMI = Formation Micro-Imager; LWSP = LANL Water Stewardship Project; NA = not applicable or not encountered; NDA = No Detectable Activity > 2 X daily- and location-specific radiological background value; Neat Cement = 95% portland cement, 5% bentonite gel; Radiological Screening peformed on cuttings for curation; SAA = same as above; TA = Technical Area; TD = Total Depth; WDC = Water Development Company.

LATA-Sharp Remediation Services, Inc.
Borehole Log

LWSP Regional Aquifer Wells
Sample Location ID: R-39

Depth (ft)	Radiological Screening	Surface Casing	Open Borehole	Cuttings Sample
85	NDA		Open Borehole	chips
90	NDA			chips
95	NDA			chips
100	NDA			chips
105	NDA			chips
110	NDA			chips
115	NDA			chips
120	NDA			chips
125	NDA			chips
130	NDA			chips
135	NDA			chips
140	NDA			chips
145	NDA			chips
150	NDA			chips
155	NDA			chips
160	NDA			chips
165	NDA			chips
170	NDA			chips
175	NDA			chips
180	NDA			chips
	NDA			chips

Lithology

tuff; vitric pumice fragments have less defined tube structures, phenocrysts are quartz and sanidine, lithics are mostly dacite, slightly magnetic from minute magnetite accessory minerals.

At 120 ft, light gray 5YR7/1 to pinksh white 5YR8/2 vitric ash flow tuff.

(139.0, 147.0)
Qbog: Increase in vitric pumice with no tube structures indicates air-fall pumice aggregate at base of Otowi Fm.

(147.0, 307.0)
Tb4: Massive aphanitic basalt, very dark gray 5YR3/1, rare vesicles to 1 mm, some tabular plagioclase laths 0.1 x 1 mm, trace olivine.

At 180 ft, slightly vesicular aphanitic basalt, dark gray 5YR4/1, equant vesicles up to 2mm in clusters.

Notes

volcaniclastic sediments indicated by some light greenish gray aphanitic dacite and weakly consolidated sandstone fragments with tuff matrix.

From 147 ft to 165 ft, mostly weathered basalt with some clay and pumice fragments.

Well Construction

Annular Backfill Material: Neat Cement

bgs = below ground surface; Concrt. = concrete; DTW = Depth to Water (ft bgs); FMI = Formation Micro-Imager; LWSP = LANL Water Stewardship Project; NA = not applicable or not encountered; NDA = No Detectable Activity > 2 X daily- and location-specific radiological background value; Neat Cement = 95% portland cement, 5% bentonite gel; Radiological Screening peformed on cuttings for curation; SAA = same as above; TA = Technical Area; TD = Total Depth; WDC = Water Development Company.

LATA-Sharp Remediation Services, Inc.
Borehole Log

LWSP Regional Aquifer Wells
Sample Location ID: R-39

Page 3 of 9

Depth (ft)	Radiological Screening	Surface Casing	Open Borehole	Cuttings Sample	Graphic Log	Lithology	Notes	Well Construction	Annular Backfill Material
185			Open Borehole						Neat Cement
190	NDA			chips					
195	NDA			chips					
200	NDA			chips					
205	NDA			chips					
210	NDA			chips					
215	NDA			chips					
220	NDA			chips					
225	NDA			chips					
230	NDA			chips			From 230 ft to 235 ft, interflow indicated by mostly vesicular basalt with 10% pumice and moderately indurated tuff fragments, some coated with light brown clay.		
235	NDA			chips		At 235 ft, massive aphanitic basalt, gray 5YR5/1, rare vesicles to 1 mm, no megascopic olivine, plagioclase, or pyroxene.			
240	NDA			chips					
245	NDA			chips					
250	NDA			chips					
255	NDA			chips		At 255 ft, slightly vesicular aphanitic basalt, gray 5YR5/1.			
260	NDA			chips					
265	NDA			chips					
270	NDA			chips					
275	NDA			chips		At 277 ft, massive aphanitc basalt, gray 7.5YR5/1 or gray 5/N.			
280	NDA			chips					
285	NDA			chips					

bgs = below ground surface; Concrt. = concrete; DTW = Depth to Water (ft bgs); FMI = Formation Micro-Imager; LWSP = LANL Water Stewardship Project; NA = not applicable or not encountered; NDA = No Detectable Activity > 2 X daily- and location-specific radiological background value; Neat Cement = 95% portland cement, 5% bentonite gel; Radiological Screening peformed on cuttings for curation; SAA = same as above; TA = Technical Area; TD = Total Depth; WDC = Water Development Company.

LATA-Sharp Remediation Services, Inc.
Borehole Log

LWSP Regional Aquifer Wells
Sample Location ID: R-39

Page 4 of 9

Depth (ft)	Radiological Screening	Surface Casing	Open Borehole	Cuttings Sample	Graphic Log	Lithology	Notes	Well Construction	Annular Backfill Material
285			Open Borehole			At 285 ft to 300 ft, 60% same as above (SAA), 40% dark reddish brown 5YR3/3 highly vesicular basalt.			Neat Cement
290	NDA			chips					
295	NDA			chips					
300	NDA			chips		At 300 ft, SAA with some basalt chips showing light yellowish brown 10YR6/4 clay coating inside vesicles.			
305	NDA			chips			No recovery, 305 ft to 310 ft, contact at 307 ft based on interpretation of geophysical logs		Bentonite Seal
310	NDA					(307.0, 337.0) Tb4 cinder: At 315 ft, reddish brown 5YR4/4 highly vesicular basaltic cinder			
315	NDA			chips					
320	NDA			chips					
325	NDA			chips					
330	NDA			chips					
335	NDA			chips					
340	NDA			chips		(337.0, 373.0) Tb4 sediments: Basalt sediments with cinder, light gray 10YR7/1, rounded, with some slight yellow clay coating.	From 340 ft lto 375 ft, less magnetic.		
345	NDA			chips					
350	NDA			chips					
355	NDA			chips					
360	NDA			chips					
365	NDA			chips					
370	NDA			chips					
375	NDA			chips		(373.0, 465.0) Tb4 Dacite: Dacite cinder, highly vesicular to frothy, and dacite pumice, light brownish gray 2.5YR6/2, ellipsoidal to equant, up to 1x1.5x2 cm, finer chips are aphanitic and massive.	From 375 ft to TD at 896 ft, slightly magnetic like above 340 ft.		
380	NDA			chips					
385	NDA			chips					

bgs = below ground surface; Concrt. = concrete; DTW = Depth to Water (ft bgs); FMI = Formation Micro-Imager; LWSP = LANL Water Stewardship Project; NA = not applicable or not encountered; NDA = No Detectable Activity > 2 X daily- and location-specific radiological background value; Neat Cement = 95% portland cement, 5% bentonite gel; Radiological Screening pefromed on cuttings for curation; SAA = same as above; TA = Technical Area; TD = Total Depth; WDC = Water Development Company.

LATA-Sharp Remediation Services, Inc.
Borehole Log

LWSP Regional Aquifer Wells
Sample Location ID: R-39

Page 5 of 9

Depth (ft)	Radiological Screening	Surface Casing	Open Borehole	Cuttings Sample	Graphic Log	Lithology	Notes	Well Construction	Annular Backfill Material
390	NDA		Open Borehole	chips					Bentonite Seal
395	NDA			chips		At 395 ft, mostly weak red 2.5YR4/2 highly vesicular frothy dacite cinder.			
400	NDA			chips		From 400 ft to 465 ft, bimodal dacite cinder 70% weak red, 30% dark reddish gray 2.5YR4/1.			
405	NDA			chips					
410	NDA			chips					
415	NDA			chips					
420	NDA			chips					
425	NDA			chips			From 425 ft to 430 ft, some cinder is ellipsoidal like airborne pumice bombs.		
430	NDA			chips					
435	NDA			chips					
440	NDA			chips					
445	NDA			chips					
450	NDA			chips					
455	NDA			chips					
460	NDA			chips					
465	NDA			chips		(465.0, 505.0) Tb4 Dacite: Dacitic sediments with cinder.			
470	NDA			chips		At 470 ft, dark reddish brown 5YR3/2 to dark gray 10YR4/1 highly vesicular dacite cinder.			
475	NDA			chips					
480	NDA			chips					
485	NDA			chips					
490	NDA			chips					

bgs = below ground surface; Concrt. = concrete; DTW = Depth to Water (ft bgs); FMI = Formation Micro-Imager; LWSP = LANL Water Stewardship Project; NA = not applicable or not encountered; NDA = No Detectable Activity > 2 X daily- and location-specific radiological background value; Neat Cement = 95% portland cement, 5% bentonite gel; Radiological Screening peformed on cuttings for curation; SAA = same as above; TA = Technical Area; TD = Total Depth; WDC = Water Development Company.

LATA-Sharp Remediation Services, Inc.
Borehole Log

LWSP Regional Aquifer Wells

Sample Location ID: R-39

Page 6 of 9

Depth (ft)	Radiological Screening	Surface Casing	Open Borehole	Cuttings Sample	Graphic Log	Lithology	Notes	Well Construction	Annular Backfill Material
490									
495	NDA			chips		At 495 ft, clay to 30%.			
500	NDA			chips		From 500 ft to 505 ft, clay to 10%.			
505	NDA			chips		(505.0, 550.0) Tb4 sediments: Bimodal 60% aphanitic dark gray basalt and 40% lighter gray dacite sediments.			
510	NDA			chips					
515	NDA			chips					
520	NDA			chips					
525	NDA			chips		At 525 ft, clay to 40% and porphyritic dacite chips.			
530	NDA			chips		At 530 ft, clay to 10%.			
535	NDA		Open Borehole	chips					
540	NDA			chips		At 540 ft, clay to 5%			Bentonite Seal
545	NDA			chips					
550	NDA			chips		(550.0, 864.0) Tb4 Dacite: Dacite lava flows			
555	NDA			chips		At 565 ft, 90% light gray dacite, 50% is highly vesicular cinder, 50% is massive aphanitic, less magnetic after 565 ft.			
560	NDA			chips					
565	NDA			chips		At 580 ft, mostly light gray aphanitc dacite and some light greenish gray 10Y7/1 matrix in highly vesicular dacite cinder.	From 565 ft to TD at 896 ft, less magnetic.		
570	NDA			chips					
575	NDA			chips			At 575 ft, few weakly oxidized ellipsoidal pumice bombs to 1x1.5x3cm.		
580	NDA			chips		At 585 ft. 100% light gray N7/ more massive, some moderately vesicular, transitional from cinder.			
585	NDA			chips					
590	NDA			chips		At 600 ft, light gray N7/ massive aphanitic dacite lava; some microvesicles.			

bgs = below ground surface; Concrt. = concrete; DTW = Depth to Water (ft bgs); FMI = Formation Micro-Imager; LWSP = LANL Water Stewardship Project; NA = not applicable or not encountered; NDA = No Detectable Activity > 2 X daily- and location-specific radiological background value; Neat Cement = 95% portland cement, 5% bentonite gel; Radiological Screening peformed on cuttings for curation; SAA = same as above; TA = Technical Area; TD = Total Depth; WDC = Water Development Company.

LATA-Sharp Remediation Services, Inc.
Borehole Log

LWSP Regional Aquifer Wells
Sample Location ID: R-39

Depth (ft)	Radiological Screening	Surface Casing	Open Borehole	Cuttings Sample	Graphic Log	Lithology	Notes	Well Construction	Annular Backfill Material
590			Open Borehole						Bentonite Seal
595	NDA			chips		At 585 ft. 100% light gray N7/ more massive, some moderately vesicular, transitional from cinder.			
600	NDA			chips		At 600 ft, light gray N7/ massive aphanitic dacite lava; some microvesicles.			
605	NDA			chips					
610	NDA			chips					
615	NDA			chips					
620	NDA			chips					
625	NDA			chips					
630	NDA			chips					
635	NDA			chips					
640	NDA			chips					
645	NDA			chips					
650	NDA			chips					
655	NDA			chips					
660	NDA			chips		At 660 ft, SAA light gray massive aphanitic dacite lava.			
665	NDA			chips					
670	NDA			chips					
675	NDA			chips					
680	NDA			chips					
685	NDA			chips					
690	NDA			chips					

bgs = below ground surface; Concrt. = concrete; DTW = Depth to Water (ft bgs); FMI = Formation Micro-Imager; LWSP = LANL Water Stewardship Project; NA = not applicable or not encountered; NDA = No Detectable Activity > 2 X daily- and location-specific radiological background value; Neat Cement = 95% portland cement, 5% bentonite gel; Radiological Screening peformed on cuttings for curation; SAA = same as above; TA = Technical Area; TD = Total Depth; WDC = Water Development Company.

LATA-Sharp Remediation Services, Inc.
Borehole Log

LWSP Regional Aquifer Wells
Sample Location ID: R-39

Page 8 of 9

Depth (ft)	Radiological Screening	Surface Casing	Open Borehole	Cuttings Sample	Graphic Log	Lithology	Notes	Well Construction	Annular Backfill Material
695	NDA		Open Borehole	chips					Bentonite Seal
700	NDA			chips					
705	NDA			chips		At 705 ft, SAA light gray massive aphanitic dacite lava.			
710	NDA			chips		At 715 ft, 50% ellipsoidal Bandelier Tuff pumice bombs 1x1.5x2cm; not in place.			
715	NDA			chips					
720	NDA			chips		At 720 ft, 100% light gray N7/ dacite lava.			
725	NDA			chips					
730	NDA			chips					
735	NDA			chips					
740	NDA			chips					
745	NDA			chips					
750	NDA			chips					
755	NDA			chips					
760	NDA			chips					
765	NDA			chips					
770	NDA			chips					
775	NDA			chips					
780	NDA			chips					
785	NDA			chips					
790	NDA			chips					
795	NDA			chips					

bgs = below ground surface; Concrt. = concrete; DTW = Depth to Water (ft bgs); FMI = Formation Micro-Imager; LWSP = LANL Water Stewardship Project; NA = not applicable or not encountered; NDA = No Detectable Activity > 2 X daily- and location-specific radiological background value; Neat Cement = 95% portland cement, 5% bentonite gel; Radiological Screening peformed on cuttings for curation; SAA = same as above; TA = Technical Area; TD = Total Depth; WDC = Water Development Company.

LATA-Sharp Remediation Services, Inc.
Borehole Log

LWSP Regional Aquifer Wells

Sample Location ID: R-39

Page 9 of 9

Depth (ft)	Radiological Screening	Surface Casing	Open Borehole	Cuttings Sample	Graphic Log	Lithology	Notes	Well Construction	Annular Backfill Material
795			Open Borehole						Bentonite Seal
800	NDA			chips					
805	NDA			chips					
810	NDA			chips					
815	NDA			chips					
820	NDA			chips					
825	NDA			chips			DTW at 824 ft bgs after well construction (11/13/08).		
830	NDA			chips		At 830 ft, SAA light gray dacite lava with 30% dark gray N4/ lava.			
835	NDA			chips					
840	NDA			chips		At 840 ft, increasing proportion of dark gray dacite lava.			
845	NDA			chips					
850	NDA			chips					
855	NDA			chips			20/40 transition sand		
860	NDA			chips		(864.0, 896.0) Tb4 Dacite: Dacite sediments	20-slot wire-wrapped screen from 859.03 ft to 869.03 ft bgs.		10/20 sand
865	NDA			chips		At 864 ft, FMI log shows base of lava flow.			
870	NDA			chips		At 870 ft, 5% to 15% well rounded clay balls with mostly SAA dark gray dacite.			
875	NDA			chips			20/40 transition sand		
880	NDA			chips		At 880 ft, small vitric pumice fragments.			Slough
885	NDA			chips		From 895 ft to 896 ft, dacitic sediments consisting of gravels and cobbles with 20% to 30% fine-grained sand consisting of rounded quartz, feldspar, pyroxene, and some magnetite.			
890	NDA			chips					
895	NDA			chips			TD = 896 ft bgs.		

bgs = below ground surface; Concrt. = concrete; DTW = Depth to Water (ft bgs); FMI = Formation Micro-Imager; LWSP = LANL Water Stewardship Project; NA = not applicable or not encountered; NDA = No Detectable Activity > 2 X daily- and location-specific radiological background value; Neat Cement = 95% portland cement, 5% bentonite gel; Radiological Screening peformed on cuttings for curation; SAA = same as above; TA = Technical Area; TD = Total Depth; WDC = Water Development Company.

Appendix C

Groundwater Analytical Results

C-1.0 SAMPLING AND ANALYSIS OF GROUNDWATER AT R-39

One groundwater-screening sample was collected at borehole R-39 during drilling at a depth of 796 ft below ground surface (bgs) within the vadose zone. This water sample most likely consists of municipal water used during drilling. An additional groundwater-screening sample was collected before well development at R-39 at a depth of 867 ft bgs within the regional aquifer (felsic sands beneath the Cerros del Rio dacitic lavas). This sample was collected within the screened interval from 859 to 869 ft bgs. The filtered samples were analyzed for cations, anions, perchlorate, and metals. A total of 10,373 gal. of groundwater was pumped from well R-39 during development.

C-1.1 Field Preparation and Analytical Techniques

Chemical analyses of groundwater-screening samples were performed at Los Alamos National Laboratory's (LANL's, or the Laboratory's) Earth and Environmental Sciences Science Division–Hydrology, Geochemistry, and Geology Group (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 (IC) 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. No groundwater samples were collected for total organic carbon (TOC) analyses at R-39 before well development. Charge balance errors for total cations and anions were generally less than ±2% 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.

C-1.2 Field Parameters

Field parameter values associated with sample number RC54-09-1036 include pH (7.78, standard units), temperature (16.7°C), dissolved oxygen (DO) (9.32 mg/L), specific conductance (253 microsiemens per centimeter), and turbidity (81 nephelometric turbidity units) for the nonfiltered groundwater sample). The low temperature measurement for this groundwater sample was probably influenced by land surface-atmosphere conditions during sampling. Regional aquifer groundwater most likely is relatively oxidizing at well R-39, based on the DO measurement, which, however, was partly influenced by aeration during sampling.

C-1.3 Analytical Results for Groundwater-Screening Samples

Analytical results for two groundwater-screening samples collected at R-39 during drilling and before well development are provided in Table C-1.3-1. Calcium and sodium are the dominant cations in predevelopment groundwater (sample RC54-09-1036) collected from well R-39. Before well development, dissolved concentrations of calcium and sodium were 13.9 and 38.3 ppm, or mg/L, respectively. Dissolved concentrations of chloride and fluoride were 6.64 and 0.54 ppm, respectively, before well development. Dissolved concentrations of nitrate(N) and sulfate were 0.061 and 18.0 ppm, respectively. Presence of residual drilling fluid (AQF-2 foam) in groundwater before well development has potentially contributed additional sodium and sulfate to the screening sample (RC54-09-1036). The concentration of perchlorate in sample RC54-09-1036 was less than analytical detection (0.005 ppm) using IC.

Before well development at R-39, dissolved concentrations of iron and manganese were 0.23 and 0.078 ppm (230 and 78 μg/L, or 230 and 78 ppb), respectively (Table C-1.3-1). The dissolved concentration of boron was 0.136 ppm in sample RC54-09-1036 collected from well R-39 before development. Dissolved concentrations of chromium and zinc were 0.004 and 0.009 ppm, respectively, in the predevelopment groundwater-screening sample collected at well R-39 (Table C-1.3-1). Dissolved concentrations of aluminum and barium were 0.515 and 0.602 ppm, respectively, in sample RC54-09-1036. Molybdenum was detected at a dissolved concentration of 0.017 ppm, which most likely is caused by the presence of a residual drilling lubricant used at R-39. Presence of naturally occurring colloids, consisting of clay minerals, ferric oxyhydroxide, and other silicates comprising the aquifer material, may have influenced concentrations of metals and trace elements measured in sample RC54-09-1036 collected before development at well R-39.

Table C-1.3-1
Analytical Results for Groundwater-Screening Samples Collected at R-39, Pajarito Canyon, New Mexico

Sample ID	Date Received	Well	ER/RRES[a]-WQH	Water Type	Depth (ft)	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)	Cd rslt (ppm)	stdev (Cd)	Cl(-) ppm	ClO4 (-) ppm	ClO4 (-) U
RC54-09-1035	11/12/2008	R-39	09-278	Borehole	796	0.001	U	1.343	0.018	0.0005	0.0000	0.153	0.001	0.554	0.007	0.001	U	0.40	No sample	12.3	0.1	0.001	U	6.57	0.005	U
RC54-09-1036	12/8/2008	R-39	09-456	Well, predevelopment	867	0.001	U	0.515	0.020	0.0081	0.0048	0.136	0.000	0.602	0.004	0.001	U	0.39	No sample	13.9	0.1	0.001	U	6.64	0.005	U

Table C-1.3-1 (continued)

Sample ID	Date Received	Well	Co rslt (ppm)	stdev (Co)	Alk-CO3 rslt (ppm)	ALK-CO3 (U)	Cr rslt (ppm)	stdev (Cr)	Cs rslt (ppm)	stdev (Cs)	Cu rslt (ppm)	stdev (Cu)	F(-) ppm	Fe rslt (ppm)	stdev (Fe)	Alk-CO3+HCO3 rslt (ppm)	Hg rslt (ppm)	stdev (Hg)	K rslt (ppm)	stdev (K)	Li rslt (ppm)	stdev (Li)	Mg rslt (ppm)	stdev (Mg)
RC54-09-1035	11/12/2008	R-39	0.001	0.000	0.8	U	0.009	0.000	0.001	U	0.009	0.000	0.95	1.36	0.02	150	0.00026	0.00001	6.30	0.04	0.035	0.002	3.79	0.01
RC54-09-1036	12/8/2008	R-39	0.001	U	0.8	U	0.004	0.000	0.001	U	0.002	0.000	0.54	0.23	0.00	136	0.00005	U	3.51	0.02	0.051	0.000	4.53	0.02

Table C-1.3-1 (continued)

Sample ID	Date Received	Well	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	NO3-N rslt	NO3-N (U)	C2O4 rslt (ppm)	Pb rslt (ppm)	stdev (Pb)	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)
RC54-09-1035	11/12/2008	R-39	0.121	0.001	0.119	0.001	39.3	0.6	0.003	0.000	0.01	0.003	U	0.01	0.002	U	0.62	0.0033	0.0000	7.84	0.21	0.007	0.000	0.001	U	0.001	U	25.9	0.2
RC54-09-1036	12/8/2008	R-39	0.078	0.008	0.017	0.000	38.3	0.1	0.002	0.000	0.01	0.003	U	0.27	0.061	0.02	0.08	0.0002	U	7.88	0.14	0.002	0.000	0.001	U	0.001	U	30.1	0.6

Table C-1.3-1 (continued)

Sample ID	Date Received	Well	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)	stdev (Ti)	Tl rslt (ppm)	stdev (Tl)	U rslt (ppm)	stdev (U)	V rslt (ppm)	stdev (V)	Zn rslt (ppm)	stdev (Zn)	TDS[b] (ppm)	Cations	Anions	Balance
RC54-09-1035	11/12/2008	R-39	55.4	0.5	0.001	U	6.02	0.078	0.001	0.001	U	0.137	0.001	0.001	U	0.0021	0.0001	0.004	0.000	0.045	0.001	286	2.82	2.89	-0.01
RC54-09-1036	12/8/2008	R-39	64.4	1.2	0.001	U	18.0	0.053	0.000	0.001	U	0.005	0.001	0.001	U	0.0011	0.0000	0.006	0.000	0.009	0.001	290	2.84	2.87	-0.01

[a] ER/RRES-WQH = Environmental Restoration/Risk Reduction and Environmental Stewardship/Water Quality and Hydrology.

[b] TDS = Total dissolved solids.

Appendix D

Borehole Video Logging
(on DVD included with this document)

Appendix E

Los Alamos National Laboratory Geophysical Logs and Schlumberger Geophysical Logging Report (on CD included with this document)

Appendix F

Aquifer Testing Report

F-1.0 INTRODUCTION

This appendix describes the hydraulic analysis of pumping tests at well R-39 located in Pajarito Canyon. The primary objective of the analysis was to determine the hydraulic properties of the formation screened by R-39. A secondary objective was to look for a cross-connection between R-39 and nearby well R-22.

Testing consisted primarily of constant-rate pumping tests. In addition to monitoring water-level response in the pumped well, water-level data were collected from all five screen intervals in R-22.

Consistent with most of the R-well pumping tests conducted on the plateau, an inflatable packer system was used in R-39 to attempt to eliminate the effects of casing storage on the test data. Unfortunately, the test pump was inadvertently placed within the well screen during initial testing. This permitted entry of air into the well and filter pack. The results of the data analysis indicated that air had become trapped in the filter pack and/or formation, causing storagelike effects in subsequent testing, as described below.

F-1.1 Conceptual Hydrogeology

R-39 is completed into the regional aquifer at the base of the Cerros del Rio formation. It is a single-screen completion with 10 ft of screen between 859.0 and 869.0 ft below ground surface (bgs). The well screen falls within dacitic lavas of the Cerros del Rio, while the filter pack extends into underlying unconsolidated sediments. The static water level measured at the onset of testing was 826.7 ft bgs. The estimated ground surface elevation at R-39 was 6580 ft above mean sea level (amsl), putting the groundwater elevation at roughly 5753 ft amsl.

Because the water level was 32.3 ft above the top of the screen that was overlain by thick lava flows, confined conditions were assumed for R-39.

F-1.2 R-39 Testing

R-39 was tested in several episodes from December 10 to December 16, 2008. Initial testing on December 10 revealed a leak in the drop pipe that was consistent with a failed check valve in the pump. The system was pulled on December 11 and rerun with an additional check valve placed above the pump. The pump inadvertently had been set inside the well screen initially. When it was rerun, it was set 11 ft higher at a position above the top of the screen.

After resetting the pump, start-up of the 24-h constant-rate test was attempted on December 12. Initially, the generator failed, foiling the preprogrammed transducer data collection scheme at the start of the test. When the pump was started, it again showed symptoms of antecedent drainage of a portion of the drop pipe. At first, no water was produced at the surface, and the automatic internal controller shutdown mechanism was tripped, signaling possible overheating of the pump motor. The pump was restarted, and eventually water was produced but with an erratic discharge rate fluctuating between about 0.5 and 1.2 gpm. Some minutes later, the pump did not produce water at all.

The pump was pulled again and leaks were discovered in the crossover assemblies above and below the inflatable packer where the pump wires passed through the packer, as well as where the nitrogen packer inflation line passed through the upper crossover assembly. The greatest leak was in the upper crossover at the nitrogen line pass-through. This leak allowed significant flow into the casing above the packer during pump operation.

The leaks were repaired in preparation for reinstalling the pump. It was not possible to pressure-test the pass-through ports to simulate the near 600-psi pressures to which they would be subjected during downhole pump operation, so there was no assurance that the repairs would be effective.

Note: The packer pass-through configuration the contractor used on R-39 is not an optimum design because the pump wires pass into and out of the discharge piping, thus requiring that the seals used at the pass-through ports remain leak-free at pressures near 600 psi—the pump output pressure. For future tests, the contractor has been asked to change the design to one that is more reliable and less susceptible to leaks.

The pump was run back into the well on December 13 and brief tests were conducted. The 24-h constant-rate pumping test was begun the next day on December 14.

Test data presented here include the tests run on December 10–11 and from December 13 to December 16. On December 10, an initial pumping event was conducted with the packer deflated to fill the drop pipe and set the discharge rate. Pumping began at 4:01 p.m. and continued for 59 min until 5:00 p.m., except for a brief shutdown early on to reverse the pump wires. Initially, the discharge rate was 4.8 gpm, gradually declining to 2.6 gpm. A manual adjustment reduced the rate to 2.2 gpm. After 30 min of recovery, the pump was run again for 30 min from 5:30 to 6:00 p.m. (trial 1). The initial discharge rate was 3.0 gpm, gradually and inexplicably declining to 2.6 gpm. Following 60 min of recovery, the well was pumped for 60 min from 7:00 to 8:00 p.m. (trial 2). The initial discharge rate was 3.3 gpm, declining inexplicably to 2.6 gpm. After 38 min, the rate was adjusted manually to 1.5 gpm.

On December 13, after two pump pulls and reinstallations, R-39 was pumped with the packer deflated to fill the drop pipe and set the discharge rate. Pumping began at 1:21 p.m. and continued for 30 min until 1:51 p.m. at a discharge rate of 1.9 gpm. This was followed by 255 min of recovery until 6:06 p.m. A final pumping trial (trial 3) was performed for 30 min until 6:36 p.m. The initial discharge rate was 2.6 gpm, gradually declining to 2.1 gpm after 10 min. Following shutdown, recovery data were collected for 744 min until 7:00 a.m. on December 14.

At that time, the 24-h constant-rate test was initiated. Pumping continued until 7:00 a.m. on December 15. Following pump shutdown, recovery data were collected for 48 h until 7:00 a.m. on December 17.

During most of the pumping events, the discharge rate declined steadily and substantially. In some cases, the change in rate was more than could be explained by the increase in pumping lift as the water level drew down. There was no obvious explanation for this, although it may have been related to inconsistent valve operation under varying backpressure conditions. Alternatively, some of this inconsistency may have been caused by varying leakage rates of water through the defective crossover ports.

As described earlier, initial installation of the pump within the well screen allowed pulling the pumping water level into the screen and may have allowed drainage of a portion of the filter pack. Subsequent test data showed storage effects associated with expansion and contraction of the trapped air when the well drew down and recovered.

F-2.0 BACKGROUND DATA

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

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

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

Subsequent pumping tests, including R-39, 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 the Technical Area 54 (TA-54) tower site from the Environmental Division–Meteorology and Air Quality Group (ENV-MAQ). The TA-54 measurement location is at an elevation of 6548 ft amsl, whereas the wellhead elevation is approximately 6580 ft amsl. The static water level was about 827 ft below land surface, making the water table elevation roughly 5753 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-39.

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

$$P_{WT} = P_{TA54} \exp\left[-\frac{g}{3.281R}\left(\frac{E_{R39}-E_{TA54}}{T_{TA54}}+\frac{E_{WT}-E_{R39}}{T_{WELL}}\right)\right]$$

Equation F-1

Where, P_{WT} = barometric pressure at the water table inside R-39,

PTA54 = barometric pressure measured at TA-54,

g = acceleration of gravity, in m/sec2 (9.80665 m/sec2),

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

ER39 = land surface elevation at R-39 site, in feet (6580 ft estimated),

ETA54 = elevation of barometric pressure measuring point at TA-54, in feet (6548 ft),

EWT = elevation of the water level in R-39, in feet (approximately 5753 ft),

TTA54 = air temperature near TA-54, in degrees Kelvin (assigned a value of 31.5 degrees Fahrenheit, or 272.9 degrees Kelvin), and

TWELL = air temperature inside R-39, in degrees Kelvin (assigned a value of 66.4 degrees Fahrenheit, or 292.3 degrees Kelvin).

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

The corrected barometric pressure data reflecting pressure conditions at the water table were compared with the water-level hydrographs to discern the correlation between the two.

F-2.1 Importance of Early Data

When pumping or recovery first begins, the vertical extent of the cone of depression is approximately limited to 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):

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

Equation F-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, and

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-39 pumping tests. As described below, antecedent drainage of a portion of the filter pack may have left air pockets in place that contributed to a casing-storagelike effect.

F-2.2 Time-Drawdown Methods

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

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

Equation F-3

Where,

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

Equation F-4

and

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

Equation F-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, and

r = distance from center of pumpage, in feet.

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

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

Equation F-6

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

Equation F-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, and

t = match-point value, in minutes.

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

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

Equation F-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

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

Equation F-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.

F-2.3 Recovery Methods

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

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

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

Equation F-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-39 pumping tests because variable current output from the electric generator induced discharge rate fluctuations.

F-2.4 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 F-11

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 F-12

To apply this procedure, a storage coefficient value must be assigned. Confined conditions were assumed for R-39. Storage coefficient values for confined conditions can be expected to range from about 10^{-5} to 10^{-3} (Driscoll 1986, 098254). 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. An assumed value of 5×10^{-4} was used for R-39.

The analysis also requires assigning a value for the saturated aquifer thickness, *b*. For calculation purposes, an arbitrary aquifer thickness of 100 ft was used. 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 arbitrarily assigned aquifer thickness value was deemed to be adequate.

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

F-3.0 BACKGROUND DATA ANALYSIS

Background aquifer pressure data collected during the R-39 tests were plotted along with barometric pressure to determine the barometric effect on water levels and to look for pumping response in R-22. Both R-39 and R-22 were monitored using nonvented transducers.

Figure F-3.0-1 shows aquifer pressure data from R-39 along with barometric pressure data from TA-54 that have been corrected to equivalent barometric pressure at the water table in feet of water. The R-39 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 dates of the pumping periods for the R-39 pumping tests are included in the figure for reference.

At first glance it appeared that swings in barometric pressure had little effect on the total aquifer pressure. However, a careful examination of the data showed a subtle, delayed response. The barometric pressure data were modified by adjusting the time factor and the magnitude until an optimum match was achieved between the modified barometric pressure curve and the apparent hydrograph.

Figure F-3.0-2 shows the correlation that was achieved for a delay of 10.5 h and a barometric efficiency of 70%. The modified barometric pressure curve-matched the apparent hydrograph reasonably well except for the pumping and recovery period where a separation between the curves was expected.

(Note that the correction algorithm was the simplest possible, i.e., a simple time delay and amplitude modification rather than superposition of multiple antecedent barometric pressure records. Thus, the correlation shown may not be optimum. However, it was adequate for the purposes of this discussion.)

Figure F-3.0-3 shows the apparent hydrograph for R-22 screen 1 plotted with the barometric pressure. A similarity between the curves was apparent, with the apparent hydrograph showing a reduced magnitude and a time delay compared with the barometric pressure curve. There was no discernible response to the R-39 pumping test.

The data from Figure F-3.0-3 were replotted in Figure F-3.0-4 with the barometric pressure curve modified for a 13-h delay and 45% barometric efficiency. This simple correction algorithm achieved a reasonable correlation between the two data plots.

Figure F-3.0-5 shows the apparent hydrograph for R-22 screen 2 plotted with the barometric pressure. A similarity between the curves was apparent, with the apparent hydrograph showing a reduced magnitude and a time delay compared with the barometric pressure curve. Again, there was no discernible response to the R-39 pumping test.

The data from Figure F-3.0-5 were replotted in Figure F-3.0-6 with the barometric pressure curve modified for a 13-h delay and 70% barometric efficiency. Again, this simple correction algorithm achieved a reasonable correlation between the two data plots.

Figure F-3.0-7 shows the apparent hydrograph for R-22 screen 3 plotted with the barometric pressure. There was little correlation between the curves, suggesting a very high barometric efficiency. Again, response to pumping R-39 was not evident. The most prominent feature of the apparent hydrograph was a low-amplitude diurnal signal. The diurnal response did not seem to correlate well with the barometric pressure curve.

The data were replotted along with run times for the Los Alamos County water production wells to check for a correlation between the subtle hydrograph signal and municipal well operation times. Figure F-3.0-8 shows the comparison.

The pumping pattern for the Los Alamos County wells was consistent for several days but then changed substantially for all four wells on December 13 and 14. Nevertheless, the timing of the diurnal signal peaks in the hydrograph remained about the same on those days. The conclusion from this was that the sinusoidal hydrograph signal was not related to operation of the municipal wells. This suggested that earth tides may have been responsible for the aquifer pressure fluctuations.

Looking back to the data for screen 2 (Figures F-3.0-5 and F-3.0-6), similar diurnal water-level peaks can be seen superimposed on the barometric response. These small perturbations likely were induced by earth tides as well.

Figure F-3.0-9 shows the apparent hydrograph for R-22 screen 4 plotted with the barometric pressure. As with screen 3, there was little correlation between the curves, suggesting a high barometric efficiency, and there was no noticeable response to pumping R-39.

The most prominent feature of the apparent hydrograph was the low-amplitude diurnal signal. Again, the diurnal response did not seem to correlate well with the barometric pressure curve.

The data were plotted in Figure F-3.0-10 along with run times for the Los Alamos County water production wells to check for a correlation between the subtle hydrograph signal and municipal well operation times. As occurred in screen 3, the screen 4 diurnal signal remained fairly steady even though the production well schedule changed dramatically after a few days. Again, it was concluded that earth tides induced the aquifer pressure fluctuations.

Figure F-3.0-11 shows the apparent hydrograph for R-22 screen 5 plotted with the barometric pressure. As with screens 3 and 4, there was little correlation between the curves, suggesting a high barometric efficiency, and there was no noticeable response to pumping R-39.

The most prominent feature of the apparent hydrograph was the low-amplitude diurnal signal. Again, the diurnal response did not seem to correlate well with the barometric pressure curve.

The data were plotted in Figure F-3.0-12 along with run times for the Los Alamos County water production wells to check for a correlation between the subtle hydrograph signal and municipal well operation times. As occurred in screens 3 and 4, the screen 5 diurnal signal remained fairly steady even though the production well schedule changed dramatically after a few days. As before, it was concluded that earth tides induced the aquifer pressure fluctuations.

F-4.0 R-39 DATA ANALYSIS

This section presents the data obtained from the R-39 pumping tests and the results of the analytical interpretations. Data are presented for the initial drop pipe fill event, trial 1, trial 2, the second drop pipe fill event, trial 3, and the 24-h constant-rate pumping test.

F-4.1 Initial Drop Pipe Fill Event

Figure F-4.1-1 shows the drawdown plot for the initial pumping event that was executed with the packer deflated. The locations of the transducer, top of well screen, and pump intake are shown for reference. Note that the pump intake was below the top of the well screen, with the pump having been inadvertently place within the screen.

The initial drawdown curve was reflective of the response with the pump running backwards. After 10 min, with no water produced at the surface, it was concluded that the electrical polarity/phase was incorrect and the pump was shut down briefly to reverse the pump wire orientation.

On restart, the pump produced 4.8 gpm initially, largely from casing storage, gradually declining to 2.6 gpm. After 21 min, the water level was pulled beneath the transducer so the drawdown could not be determined. It is likely that the level reached the pump intake a few minutes later and that the discharge rate declined with increasing pumping time, as would be expected in a constant-drawdown test. After 45 min, the rate was manually adjusted to 2.2 gpm for the balance of the pumping duration.

Pulling the pumping water level into the well screen allowed for the possibility of dewatering a portion of the filter pack and trapping air in the pore spaces in the filter pack behind the blank casing just above the screen. Subsequent data were consistent with this idea, as described below.

Figure F-4.1-2 shows the recovery data recorded following pump shutdown. Because the packer was deflated, conventional casing storage was expected to affect the data.

Calculations using Equation F-2 and subsequent specific capacity data from R-39 revealed an expected casing-storage duration of 150 min. Experience has shown that the theoretical calculation is conservative, and that for practical purposes, casing-storage effects are greatly diminished in about half the calculated time—in this case, 75 min. This meant that data before 75 min could not be analyzed by any method. Because the recovery duration was only 30 min, casing-storage effects were bound to render the entire data set unusable. Note that the transmissivity computed from the casing-storage slope was 21.5 gpd/ft. A transmissivity value determined from casing-storage data obtained without the use of an inflatable packer is always several times lower than the true value, so 21.5 gpd/ft is a great underestimate of the true transmissivity.

After 20 min of recovery, the packer was inflated in preparation for conducting trial 1. The dramatic slope change shown in Figure F-4.1-2 that occurred when the packer was inflated indicated a substantially reduced storage effect, implying a relatively minor degree of filter pack drainage.

F-4.2 Trial 1

Trial 1 consisted of pumping R-39 for 30 min followed by 60 min of recovery. Figure F-4.2-1 shows a semilog plot of the trial 1 drawdown data. The initial measured discharge rate was 3.0 gpm, gradually declining to 2.6 gpm.

The early data showed conventional straight-line response, with a sudden slope change after about a minute of pumping. Monitoring the flow meter showed that water was not produced at the surface for 58 s after starting the pump. Subsequent retrieval of the pump showed that the lower portion of the drop pipe (between the packer and nearest overlying check valve) had drained during recovery events. The computed corresponding volume of drained pipe was 8.9 gal. This meant that on start-up, the pump operated against low-pressure head while filling the drained portion of the drop pipe and therefore produced a greater rate than when operating against the full column of water in the drop pipe.

Assuming that the pump filled 8.9 gal. of drop pipe volume in 58 s, the estimated pumping rate was 9.2 gpm at early time. (Although this range in magnitude of flow rate and pressure head fell off the published performance curve for the pump used in the test, extrapolating the published curve to low pressure head yielded an estimated flow rate consistent with this.) This led to a calculated transmissivity of 93 gpd/ft for the early-time response. Based on the screen length of 10 ft, this made the calculated hydraulic conductivity 9.3 gpd/ft^2, or 1.24 ft/d. It was expected that these computed values were lower bounds because any amount of trapped air in the filter pack would have expanded during water-level decline, causing a minor casing-storagelike effect and therefore a slight underestimate of transmissivity.

Once the void in the drop pipe was refilled, the discharge rate declined and the drawdown diminished slightly before resuming a slow steady increasing trend. The drawdown curve flattened substantially at late time, consistent with most observed pumping test response on the plateau, presumably in response to vertical growth of the cone of depression. Alternatively, increases in lateral hydraulic conductivity could have contributed to the flattening of the drawdown curve.

An additional contributing factor in the flattening of the curve was a gradual reduction in discharge rate, from 3.0 gpm early on to 2.6 gpm just before pump shutoff. This reduction in flow rate was greater than could be explained based on the pump performance curve and the increase in hydraulic lift over time.

Note that the drawdown illustrated in Figure F-4.2-1 showed effective pumping water levels beneath the position of the pressure transducer and even beneath the pump intake. This implied that a vacuum had been created and maintained beneath the packer during the test. Because the effective level was below the top of the well screen, however, it provided an opportunity for additional air to enter the well and filter pac—through the formation itself, for example. Subsequent observations suggested that the storage effects had become more pronounced.

Figure F-4.2-2 shows the recovery data measured following trial 1. The data showed classic storage-affected response, with an erroneous transmissivity value of 6 gpd/ft computed from the storage portion of the curve.

The recovery rate was sluggish in comparison to the drawdown rate shown in Figure F-4.2-1, even accounting for changes in discharge rate (9.2 gpm at the outset of pumping versus an effective rate of 2.6 gpm at the outset of recovery). This suggested a stronger storagelike effect than had occurred at the onset of pumping, supporting the idea of additional entry of air into the well during pumping.

The late-recovery curve showed the characteristic flattening, generally associated with vertical growth of the cone of depression and possible other causes cited earlier.

F-4.3 Trial 2

Trial 2 consisted of pumping R-39 for 60 min followed by 857 min of recovery. Figure F-4.3-1 shows a semilog plot of the trial 2 drawdown data. The initial measured discharge rate was 3.3 gpm, gradually declining to 2.6 gpm. Toward the end of the test, the rate was adjusted manually to 1.5 gpm.

In contrast to trial 1 (Figure F-4.2-1), the early data showed obvious storage-affected response (curved data trace, rather than straight), with a sudden inflection after about 35 s of pumping. This change in the form of the curve was consistent with the idea that additional air had been entrained in the filter pack during trial 1, exacerbating the storage effect for subsequent tests. Further evidence of this is that during the first half minute of pumping, the drawdown in trial 2 was consistently less than in trial 1, for example, 20 ft of drawdown after 30 s in trial 2 compared with 33 ft in trial 1.

Monitoring the flow meter showed that water was not produced at the surface for nearly 40 s after starting the pump. As had occurred in trial 1, on start-up, the pump operated against low-pressure head while filling the drained lower portion of the drop pipe and therefore produced at a high flow rate, presumably the same 9.2 gpm rate estimated for trial 1.

The drawdown trend just before the inflection was extrapolated to compute a transmissivity value. The result was a transmissivity of 101 gpd/ft and a hydraulic conductivity of 10.1 gpd/ft^2, or 1.35 ft/d. These values were considered lower-bound estimates of aquifer properties because they were based on storage-affected data.

Late data showed that the effective pumping water level was drawn below the top of the well screen again, allowing the possibility of further air entrainment in the well and filter pack. Toward the end of the test, the discharge rate was adjusted manually to 1.5 gpm. The resulting recovery was uniform for awhile but then became more erratic at the end of the test. This could have been caused by dynamic changes in the leakage rates through the upper and lower crossover assemblies at the packer. It is also possible that air entered the casing beneath the packer, inducing errors in the transducer readout.

(Note that when the transducer is under vacuum conditions, an air space beneath the inflatable packer will cause the transducer reading to no longer accurately represent actual ongoing pressure changes. For example, F-4.2-1 [trial 1] shows more than 49 ft of drawdown after 30 min of pumping with a final rate of 2.6 gpm, whereas Figure F-4.3-1 [trial 2] shows less than 45 ft of drawdown after 30 min of equivalent pumping. This apparent difference is not real but an artifact of the transducer output under vacuum conditions with an air space in the casing.)

Figure F-4.3-2 shows the recovery data recorded following shutdown of trial 2. The data showed that the measured head rose more than 20 ft above the original static water level, fluctuated over time, but remained above the static level overnight and into the next morning.

This indicated that water had leaked into the casing annulus above the packer through the upper crossover fitting during the test and was leaking back into the formation (through both the upper and lower crossovers) during recovery. This response was not observed in trial 1, so there were dynamic changes in the character of the leaks between trials 1 and 2.

F-4.4 Packer Deflation

Following trial 2, the downhole packer was deflated so that the pump string could be removed and the leaks diagnosed and repaired. This allowed the weight of the trapped water above the packer, which had leaked through the crossover assemblies, to be delivered to the pressure transducer while the water drained back into the well and formation.

Figure F-4.4-1 shows the resulting head buildup and decay that occurred when the packer was deflated. Also shown on the graph are the computed “injection” rates of water moving from the well casing into the aquifer and the effective injection specific capacity (ratio of inflow rate to head buildup). After packer deflation, the head in the casing above the transducer increased nearly 90 ft and then slowly declined.

The injection rate ranged between about 3 and 4 gpm, while the specific capacity was 0.05 gpm/ft. The apparent rise in specific capacity at 5 min was not real but an artifact of lifting the pipe string in preparation for removal. This vertical translation of the transducer altered the calculation of the descent rate of the apparent water level. Of interest was that the short-term injection specific capacity (0.05 gpm/ft) was about 50% of the short-term pumping specific capacity (0.1 gpm/ft).

F-4.5 Second Drop Pipe Fill Event

After the pump was pulled and the leaks were diagnosed in the crossover assemblies, repairs were made, and the pump was reinstalled for the final round of testing. For this installation, the pump was set just above the top of the well screen. Figure F-4.5-1 shows the drawdown plot for the initial pumping event, which was executed with the packer deflated. Within 4 min of start-up, the pumping water level was pulled beneath the pressure transducer for the remainder of the fill event.

Figure F-4.5-2 shows the recovery data recorded following pump shutdown. Both the drawdown and recovery data were dominated by casing-storage effects, as expected with the packer deflated.

F-4.6 Trial 3

A third pumping trial was performed after packer inflation. The well was pumped for 30 min followed by 744 min of recovery. Figure F-4.6-1 shows the semilog drawdown curve. The initial discharge rate was 2.6 gpm, gradually declining to 2.4 gpm after 6 min. This rate reduction was consistent with the increase in pumping lift over that time period, based on the pump performance curve.

Over the next 4 min, however, the discharge rate dropped rapidly to 2.1 gpm. It appeared that the effective pumping water level dropped below the pressure transducer and probably reached the pump intake. Thereafter, the pumping level could not drop farther and thus the discharge rate declined as it would in a constant-drawdown pumping test.

This combination of symptoms implied the possibility of air moving into the casing beneath the inflatable packer. Note the slight decline in measured head between 6 and 10 min. This was different than the significant ongoing decline in head measured in trial 1 (Figure F-4.2-1) after the effective pumping level was pulled beneath the transducer (and even beneath the pump intake). It appeared that a substantial vacuum had been maintained beneath the packer during trial 1 but not during trial 3.

The balance of the trial 3 pumping event was used to adjust the discharge rate in preparation for the 24-h pumping test. The measured pumping rate at the end of the test was 1.2 gpm.

Figure F-4.6-2 shows the recovery data recorded overnight after pump shutdown.

The data showed clear storage effects and were not analyzable.

F-4.7 R-39 24-H Constant-Rate Pumping Test

Figure F-4.7-1 shows a semilog plot of the drawdown data recorded during the 24-h constant-rate pumping test conducted at R-39. There were several points of interest revealed by the data.

First, it appeared that a portion of the drop pipe string had drained overnight, based on the abrupt inflection observed after about 0.2 min of pumping.

Second, the data further supported the idea of increased trapped air in the filter pack and a stronger storage effect than observed originally in trial 1 (Figure F-4.2-1). A comparison of the drawdown at 0.2 min in Figures F-4.2-1 and F-4.7-1 showed that the original test produced nearly triple the drawdown observed in the latest test, even though the discharge rates were presumably identical (about 9.2 gpm against minimal pumping head while the drop pipe refilled). Increased storage effects contributed to the more sluggish response in the 24-h test.

Third, there were small fluctuations in the drawdown (and measured discharge rate) during most of the test period. There was no obvious explanation for this anomaly.

Finally, the pumping rate was about 1.7 gpm, even though the gate valve setting in the discharge piping had not been changed since the previous day when the rate was adjusted to 1.2 gpm. This illustrated the sensitivity of the valve operation to changes in applied pressure and the possibility of valve-induced discharge rate fluctuations.

Combined with flow-rate fluctuations later, the storage effects early on rendered the drawdown data unusable for determining aquifer coefficients.

Figure F-4.7-2 shows the recovery data recorded following pump shutdown. The early data were clearly storage affected and not analyzable. The late data showed flattening associated with vertical expansion of the cone of depression.

Figure F-4.7-3 shows an expanded-scale graph of the recovery data emphasizing the late, poststorage response.

The line of fit on the graph provided a calculated transmissivity of 5600 gpd/ft. This was interpreted as the transmissivity of the contiguous hydraulic unit between the static water level (or lava flows) and an aquitard at some unknown distance beneath the well screen.

The timing of the deviations of the data points above and below the line of fit is fully consistent with expectations based on barometric pressure fluctuations (Figures F-3.0-1 and F-3.0-2).

F-4.8 Final Packer Deflation

Following the 24-h pumping and recovery test, the downhole packer was deflated so that the pumping string could be removed from the well. When the packer was deflated, the head over the transducer rose several feet, indicating that water had leaked into the annulus above the packer during the test. After deflation, the trapped water above the packer was delivered to the pressure transducer while the water drained back into the well and formation. It is likely that the pass-through ports in the packer crossover assemblies had continued to leak slowly even after being repaired. This emphasized the inadequacy of the packer design used for the R-39 pumping tests.

Figure F-4.8-1 shows the resulting head buildup and decay that occurred when the packer was deflated. Also shown on the graph are the computed “injection” rates of water moving from the well casing into the aquifer and the effective injection specific capacity (ratio of inflow rate to head buildup). After packer deflation, the head in the casing above the transducer increased nearly 6 ft and then slowly declined.

The injection rate ranged between about 0.1 and 0.4 gpm for most of the observation period, while the specific capacity averaged more than 0.09 gpm/ft. Curiously, the injection specific capacity was nearly as great as the short-term pumping specific capacity (0.1 gpm/ft).

Recall that at an injection rate of 3 gpm, as described earlier, the injection specific capacity dropped nearly in half to 0.05 gpm/ft. The rate of 3 gpm was not sufficient to induce significant turbulent flow, so the loss of specific capacity must be related to some other dynamic effect, such as pressing the filter pack against the formation, compressing the formation sediment grains together, etc.

F-4.9 Specific Capacity Data

Specific capacity data were used along with well geometry to estimate a lower-bound conductivity value for the formation adjacent to R-39 for comparison to the pumping test value. In addition to specific capacity, other input values used in the calculations included an arbitrary aquifer thickness of 100 ft, a storage coefficient of 5 × 10–4 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-39 produced 1.7 gpm with a drawdown of 18.4 ft after 24 h of pumping for a specific capacity of 0.092 gpm/ft. Applying the Brons and Marting method to these inputs yielded a lower-bound hydraulic conductivity value for the screened interval of 7.15 gpd/ft^2, or 0.96 ft/d. This result was consistent with the lower-bound hydraulic conductivity value obtained from trial 1 of 1.24 ft/d and from the value from trial 2 of 1.35 ft/d.

F-4.10 Discussion of Possible Cross-Connection between R-22 and R-39

As discussed earlier, there was no discernible effect in R-22 while pumping R-39 at 1.7 gpm for 24 h. Analytical calculations using the Theis equation were performed to check the correspondence between this observation and the estimated aquifer properties. Distance-drawdown information was generated for a pumping rate of 1.7 gpm, a pumping time of 1 d, a transmissivity of 5600 gpd/ft (the late-time transmissivity estimated from the recovery data), and a range of storage coefficient values.

Figure F-4.10-1 shows the results computed for three storage coefficient values. According to the figure, for a typical confined storage coefficient value of 0.0005, the 24-h pumping stress should have caused nearly 0.08 ft of drawdown in R-22. Reviewing the R-22 hydrograph data (Figures F-3.0-3, F-3.0-5, F-3.0-7, F-3.0-9, and F-3.0-11), it appears that a drawdown of this magnitude would have been evident in the data plots. There are two possible explanations for the lack of an observable response in R-22.

First, if leaky conditions exist, the effective storage coefficient at late pumping time might have been greater than the typical range for confined aquifers. This in turn would imply a lower transmissivity than 5600 gpd/ft because the late-time slope in Figure F-4.7-3 would be artificially flattened by the leakage. Figure F-4.10-1 shows drawdown that would have resulted for storage coefficient values of 0.002 and 0.05. For storage coefficient values greater than about 0.002, the theoretical drawdown prediction at R-22 was a few hundredths of a foot or less—a response magnitude that could have gone undetected. Thus, slight leakage could explain the lack of an observable pumping response in R-22. It must be considered that any analysis such as this assumes uniform, homogeneous conditions. However, the flattening of the recovery curves at late times suggests the possibility of a complex (heterogeneous) aquifer and that there may be zones near the pumped section that are characterized with contrasting groundwater properties.

Second, it is possible that such geologic complexity—dipping beds, faulting, or other factors—effectively hydraulically separate R-22 and R-39 to a greater extent than if they penetrated the same homogeneous aquifer. Indeed, the rock types are different at R-22 and R-39.

In conflict with the lack of a pumping response in R-22 during the R-39 test was the observation of a water-level spike on November 12, 2008, while air drilling was performed on R-39, as shown in Figure F-4.10-2. As indicated, water-level monitoring data from R-22 screen 2 showed a rapid rise of 0.2 ft that decayed away for a little over an hour, followed by a similar magnitude water-level decline, with water levels recovering to near static in about an hour. It was surmised that this may have been a hydraulic response induced by injection and release of compressed air while drilling the R-39 borehole.

An attempt was made to simulate this response by using the Theis equation and simple injection and release of water to the formation at R-39. Calculations were performed initially for a transmissivity of 5600 gpd/ft and a confined storage coefficient of 0.0005. Injection and pumping rates and durations were varied, looking for combinations that replicated the observed magnitude rise and drawdown of 0.2 ft observed on November 12. Figures F-4.10-3 and F-4.10-4 show two examples of the results of the calculations.

In general, shorter injection and pumping periods required greater flow rates to replicate the observed water-level deflection. In all simulations, unrealistically large flow rates and durations were required to mimic the observed water-level fluctuations. Also, in all simulations, it was not possible to restore water levels back to static in the short time that was observed.

Further, if a greater storage coefficient value was assumed, as suggested by Figure F-4.10-1, accurate simulation of the water-level response required proportionately greater transmissivity (in conflict with the idea that a greater storage coefficient could imply a smaller transmissivity [Figure F-4.7-3 analysis]) and greater flow rates. This may suggest that the Theis model does not adequately describe the hydraulic system because of inherent hydrogeological complexity and that a more complex analysis would be required. For example, the quick recovery response that cannot be simulated using the Theis equation may be caused by properties of the phreatic zone near R-22.

If the water-level spike in R-22 screen 2 was caused by the drilling activities, these results suggest that compressed air pushing water into the aquifer and then air-lifting it out again may not have been sufficient to cause the observed response. It is possible that compressed air moved through the vadose zone and effected pressure changes in a different way than could be achieved by simply displacing water in the formation and pumping it back out again, although this is conjectural. In any event, there was no way to interpret the observed R-22 pressure response using the Theis equation in a way that would shed light on the aquifer properties at R-39.

F-5.0 SUMMARY

Constant-rate pumping tests were conducted on R-39 in Pajarito Canyon. The tests were conducted to gain an understanding of the hydraulic characteristics of the aquifer. Additionally, nearby well R-22 was monitored to check for hydraulic cross-connection to R-39. Numerous observations and conclusions were drawn for the tests as summarized below:

Water-level data from R-39 showed a barometric efficiency of about 70% with a lag time of about 10.5 h.

R-22 screens 1 and 2 showed barometric efficiencies of 45% and 70%, respectively, with a lag time of about 13 h. R-22 screens 3, 4, and 5 were nearly 100% barometrically efficient and exhibited diurnal fluctuations attributed to earth tides. Screen 2 showed this diurnal response also.

None of the screen zones in R-22 showed a discernible response to pumping R-39.

The pump was inadvertently set in the well screen for the initial tests on R-39. This, coupled with the low specific capacity of the well, allowed dewatering a portion of the filter pack, inducing a storage effect similar to casing storage in subsequent tests.

The inflatable packer pass-through ports for the nitrogen supply line and pump wires leaked, affecting a number of the tests. It was necessary to pull, repair, and replace the pumping assembly a couple of times. The packer setup the contractor used was not optimal and will be modified for future pumping tests.

The storage effects caused hydraulic conductivity values to be underestimated. The early tests had smaller storage effects than subsequent tests. The average lower-bound hydraulic conductivity estimate from these early tests was about 1.3 ft/d for the 10 ft of formation penetrated by the well screen. The degree of hydraulic conductivity underestimation from the early tests was probably not severe.

Specific capacity data yielded a lower-bound hydraulic conductivity estimate of 0.96 ft/d, consistent with the values from the pumping test.

Late-recovery data from the 24-h pumping test revealed a transmissivity of 5600 gpd/ft for the hydraulic unit penetrated by R-39. The effective thickness of the zone was not known because an underlying aquitard was not identified during the drilling process.

Using the estimated transmissivity value of 5600 gpd/ft and a confined storage coefficient value implied a drawdown at R-22 of 0.08 ft, large enough that it should have been visible on the hydrograph data. The lack of a discernible response in R-22 suggested either a greater storage coefficient (leaky conditions perhaps) or some sort of geologic/hydraulic barrier hindering transmission of hydraulic pressure between the wells.

A 0.2-ft magnitude head rise and drawdown observed in R-22 screen 2, presumably caused by air drilling R-39, could not be explained by aquifer hydraulics alone. Because the response suggests potential hydraulic connection between the R-22 screen 2 and R-39, additional analysis may be required to evaluate the hydraulic properties of the regional aquifer based on this observation.

Injection that occurred during instances of packer deflation when water trapped above the packer flowed into the formation revealed injection specific capacities of more than 0.09 gpm/ft at subgallon per minute flow rates (similar to pumping specific capacity) but half that at higher flow rates. The greater flow rate and applied head apparently caused some sort of dynamic permeability change, perhaps at the borehole face, reducing the flow capacity.

F-6.0 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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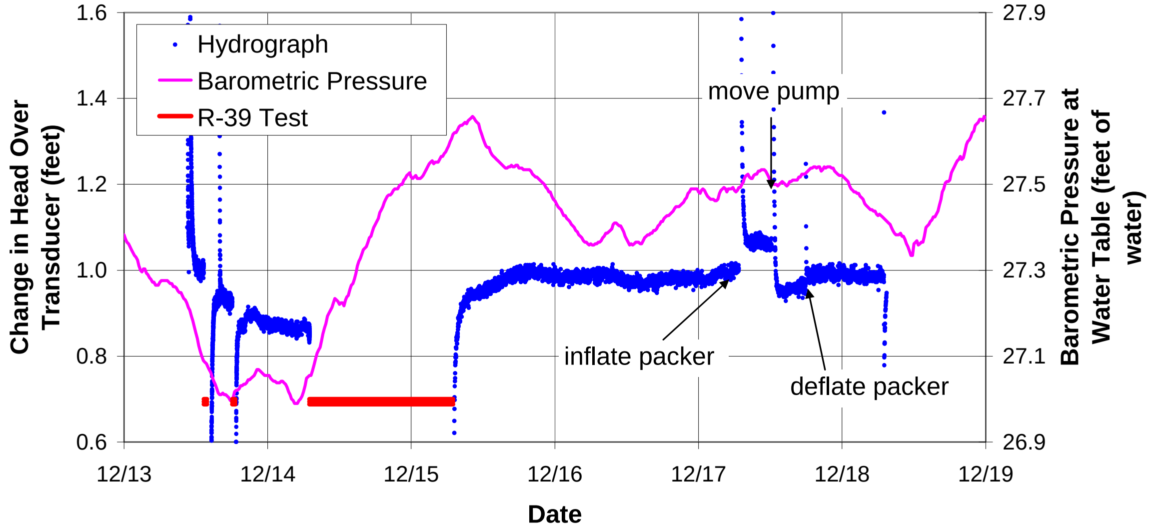

Figure F-3.0-1 Comparison of R-39 apparent hydrograph and adjusted TA-54 barometric pressure

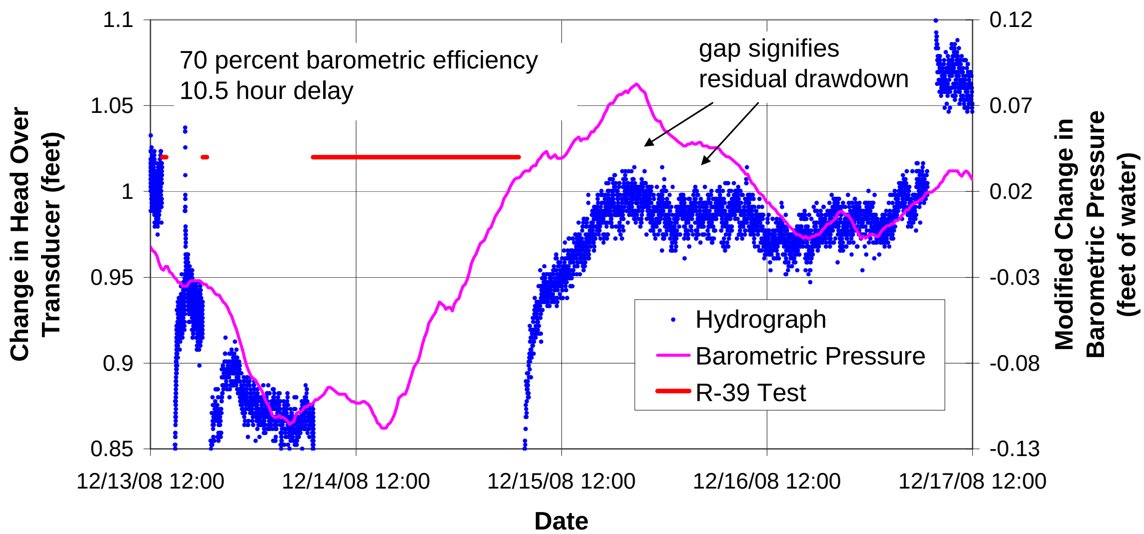

Figure F-3.0-2 Comparison of R-39 apparent hydrograph and modified TA-54 barometric pressure

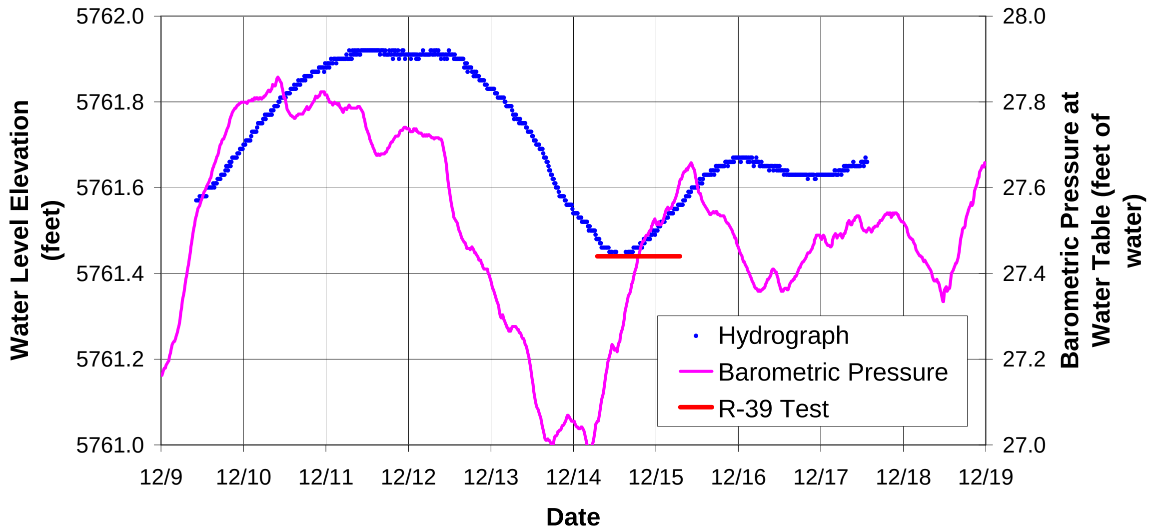

Figure F-3.0-3 Comparison of R-22 screen 1 apparent hydrograph and adjusted TA-54 barometric pressure

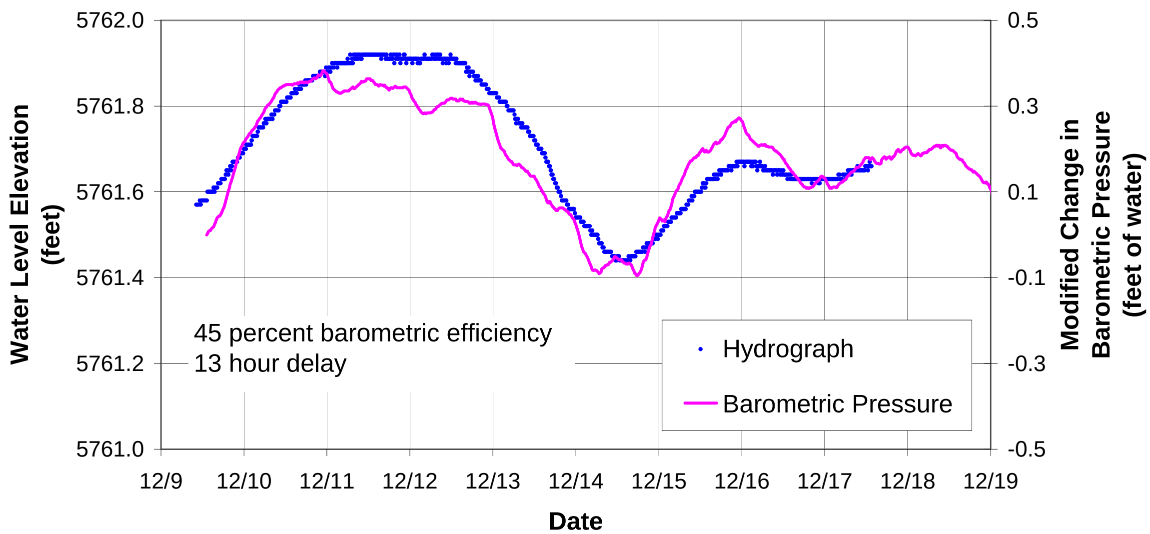

Figure F-3.0-3 Comparison of R-22 screen 1 apparent hydrograph and modified TA-54 barometric pressure

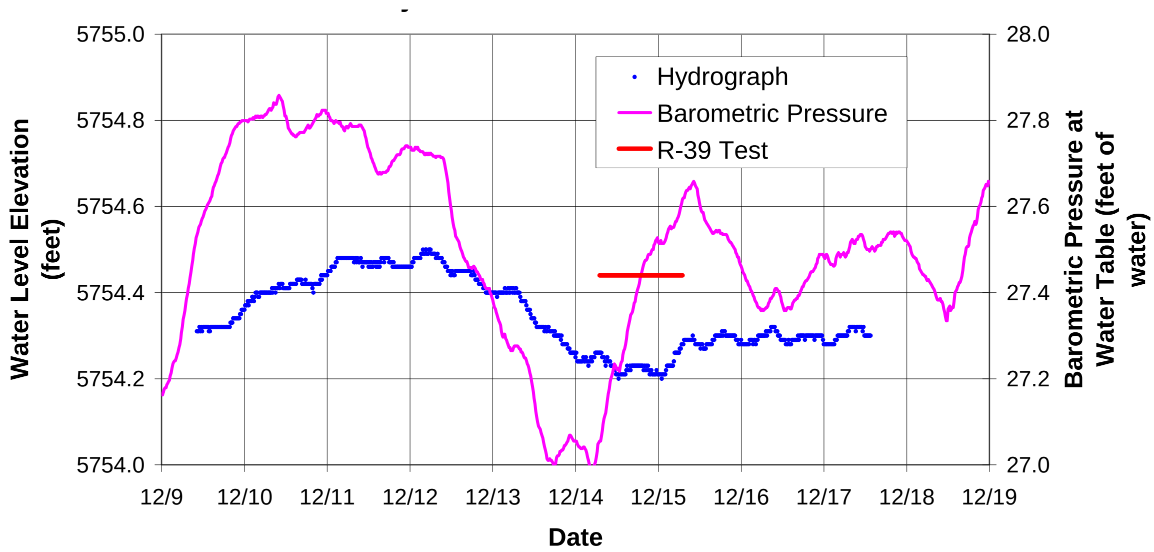

Figure F-3.0-5 Comparison of R-22 screen 2 apparent hydrograph and adjusted TA-54 barometric pressure

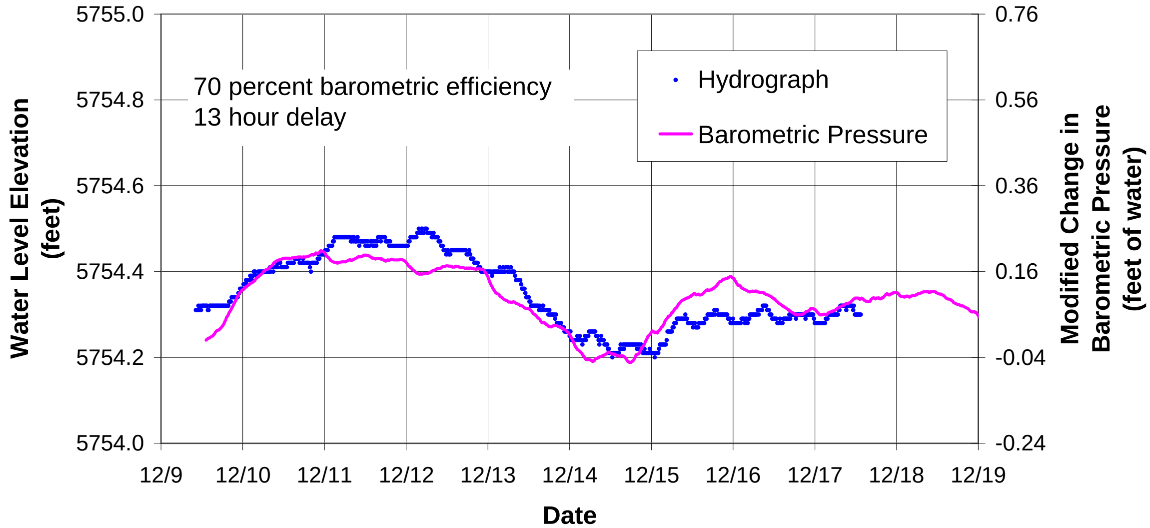

Figure F-3.0-6 Comparison of R-22 screen 2 apparent hydrograph and modified TA-54 barometric pressure

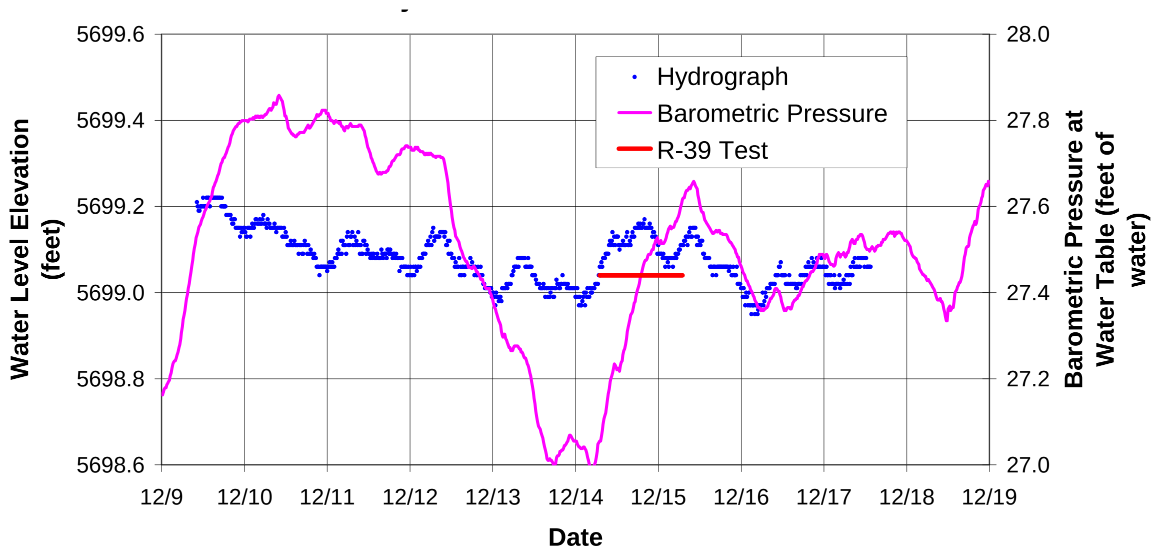

Figure F-3.0-7 Comparison of R-22 screen 3 apparent hydrograph and adjusted TA-54 barometric pressure

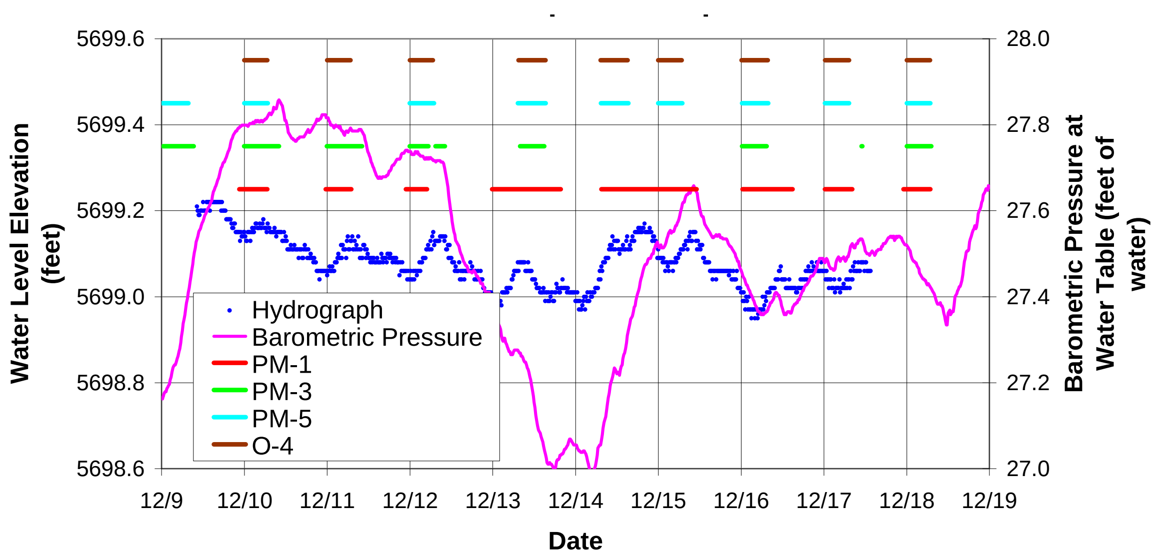

Figure F-3.0-8 Comparison of R-22 screen 3 apparent hydrograph and municipal well operation

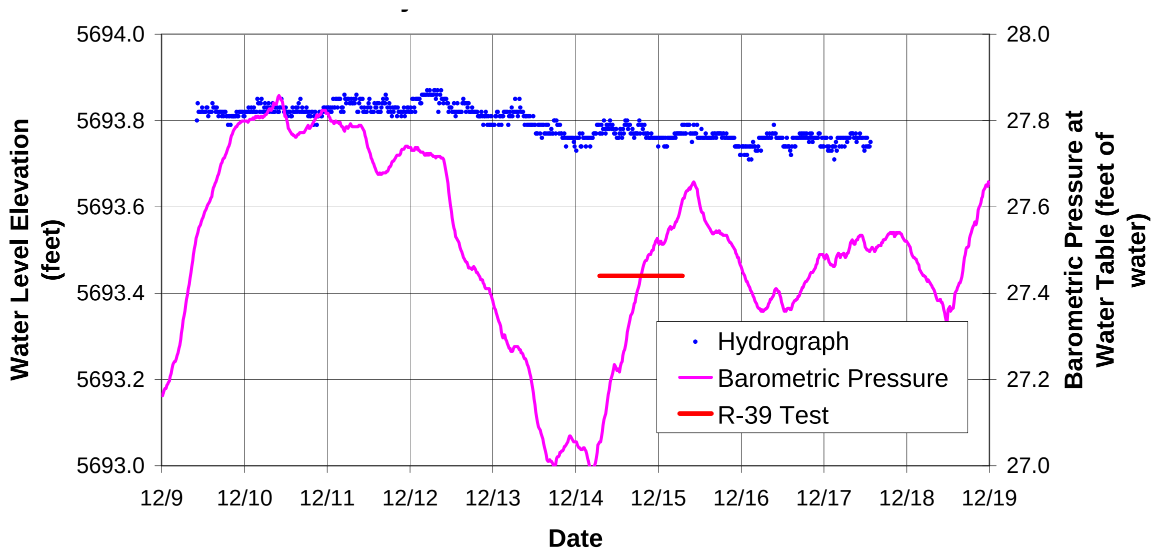

Figure F-3.0-9 Comparison of R-22 screen 4 apparent hydrograph and adjusted TA-54 barometric pressure

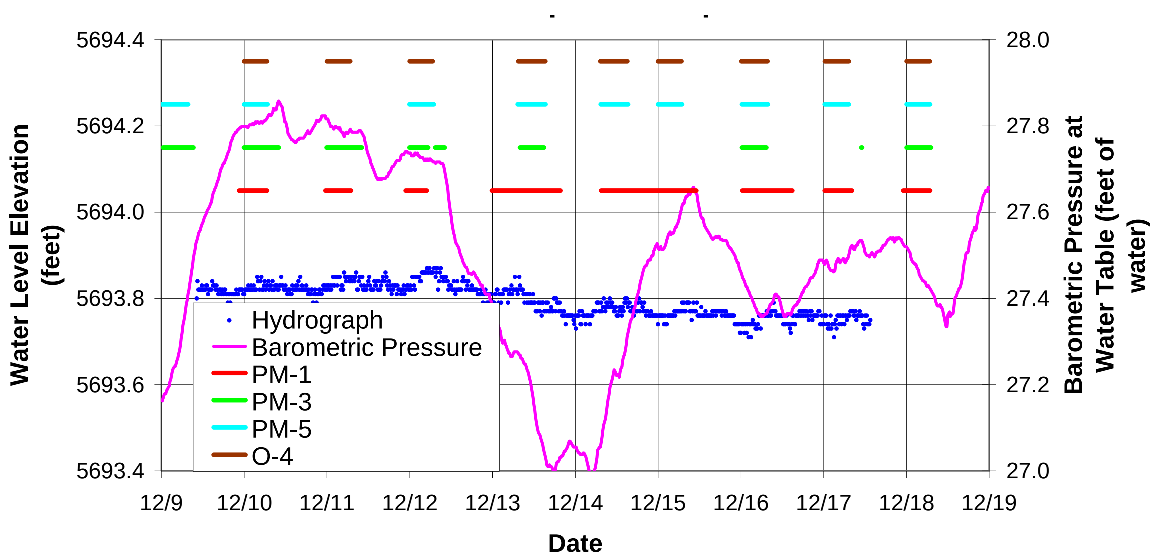

Figure F-3.0-10 Comparison of R-22 screen 4 apparent hydrograph and municipal well operation

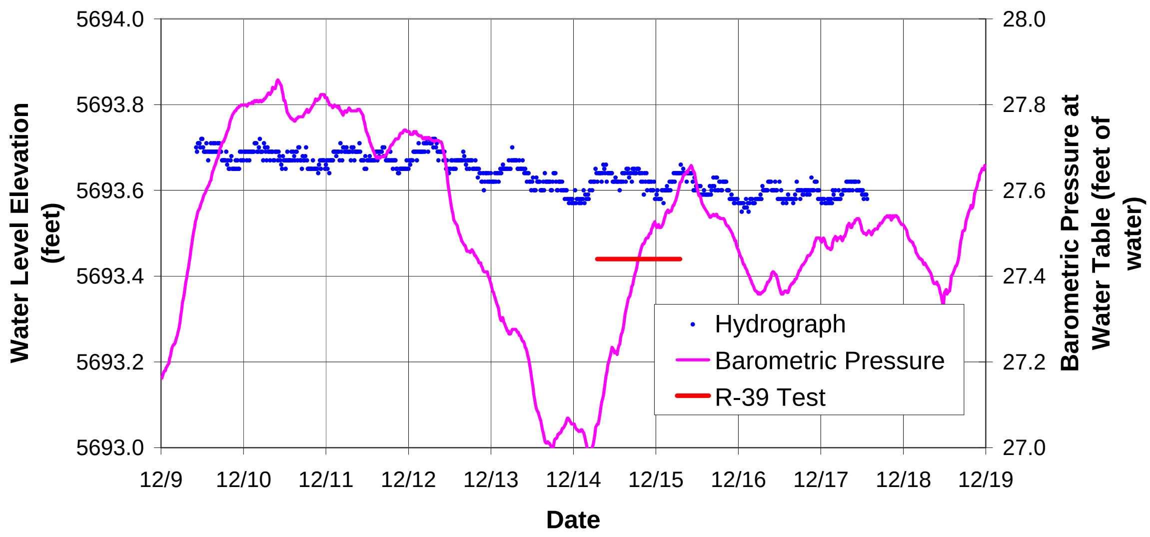

Figure F-3.0-11 Comparison of R-22 screen 5 apparent hydrograph and adjusted TA-54 barometric pressure

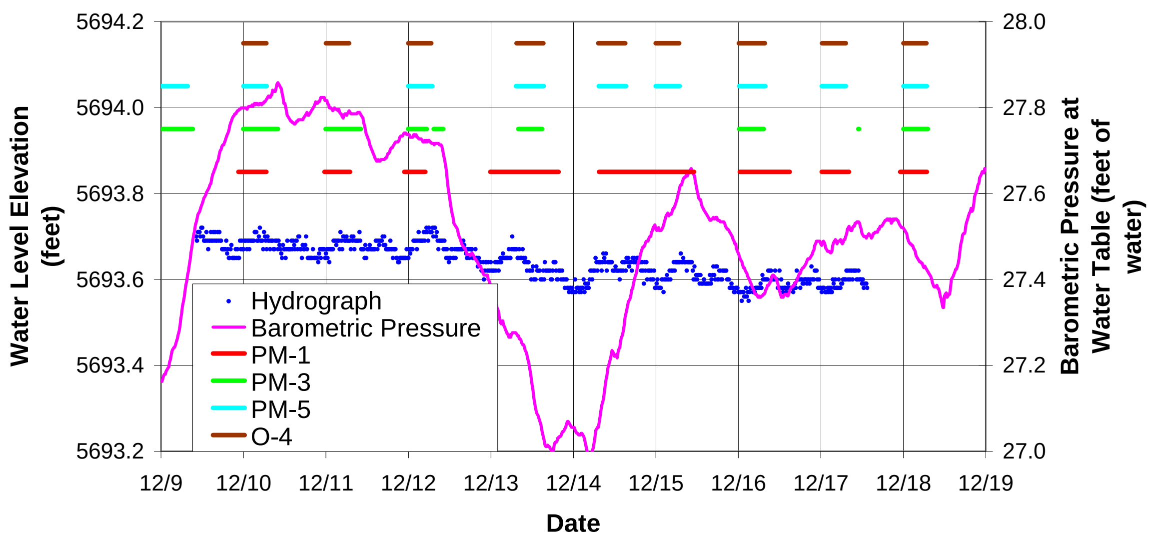

Figure F-3.0-12 Comparison of R-22 screen 5 apparent hydrograph and municipal well operation

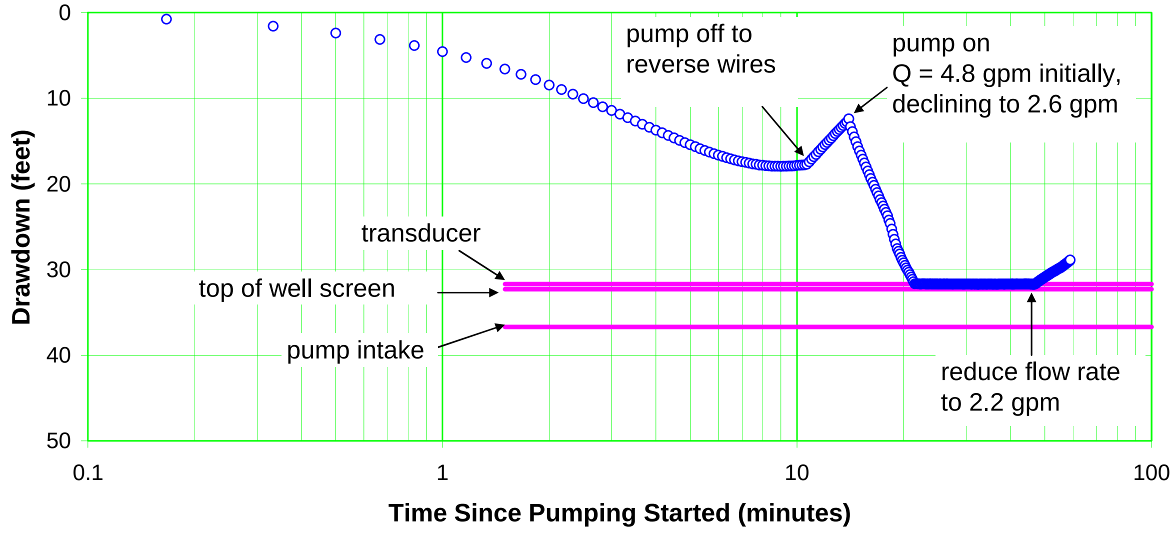

Figure F-4.1-1 Well R-39 initial drop pipe fill drawdown

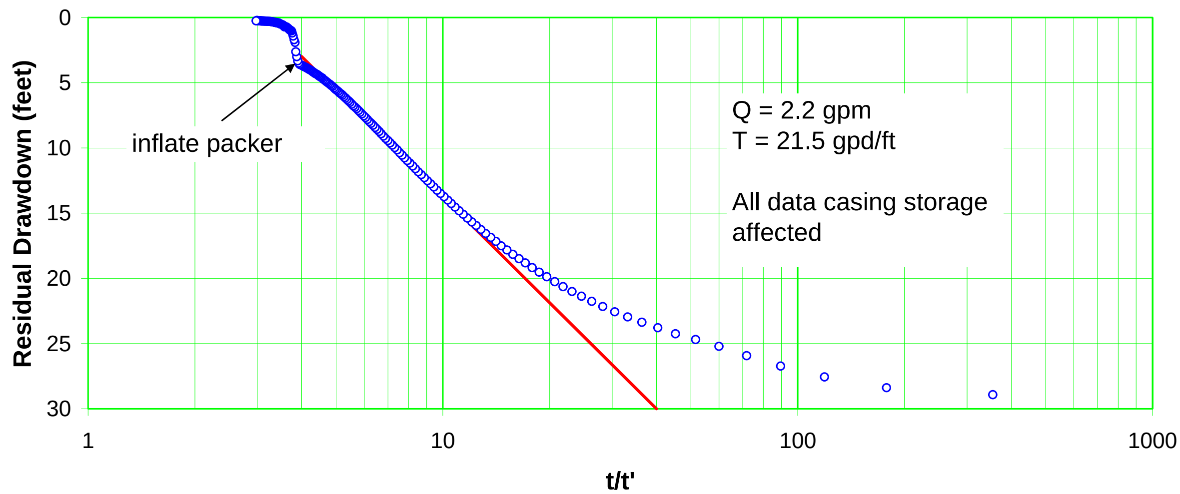

Figure F-4.1-2 Well R-39 initial drop pipe fill recovery

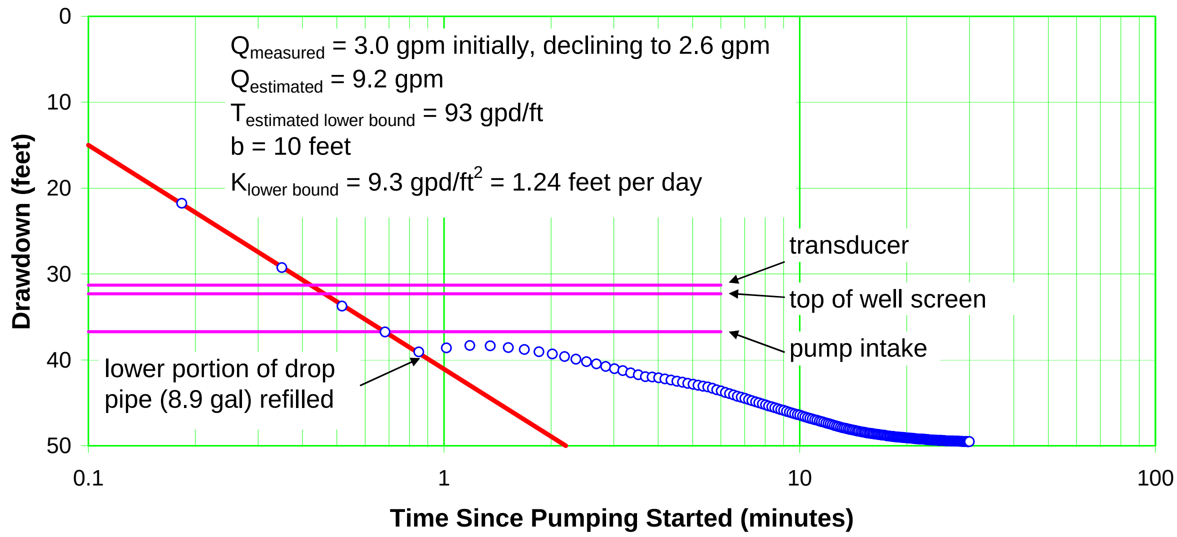

Figure F-4.2-1 Well R-39 trial 1 drawdown

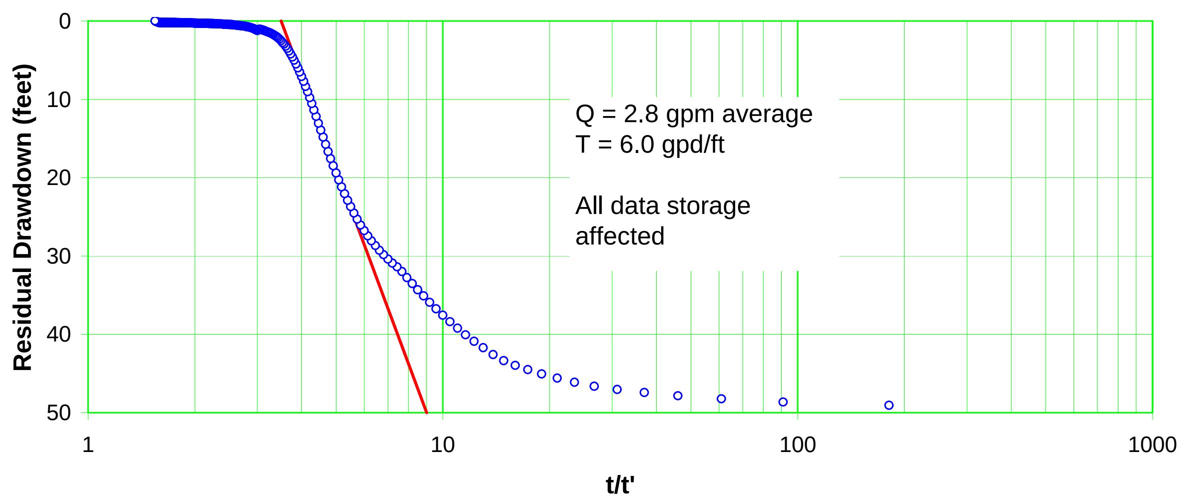

Figure F-4.2-2 Well R-39 trial 1 recovery

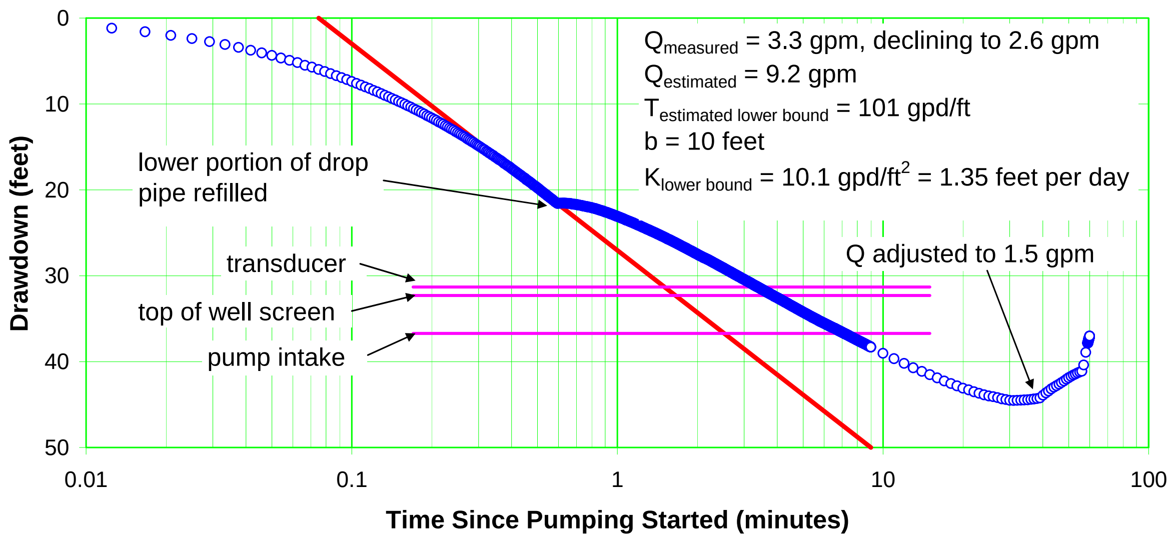

Figure F-4.3-1 Well R-39 trial 2 drawdown

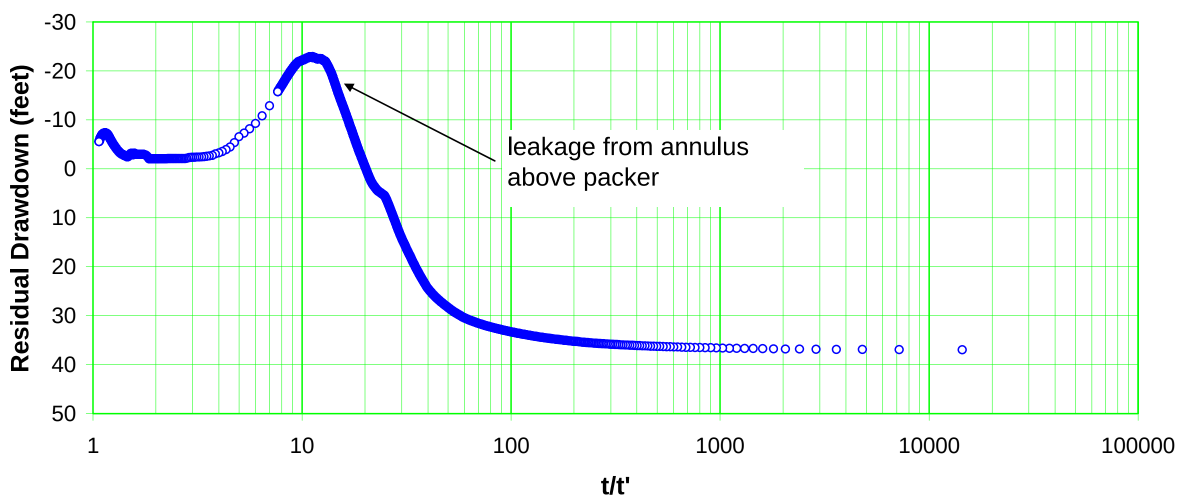

Figure F-4.3-2 Well R-39 trial 2 recovery

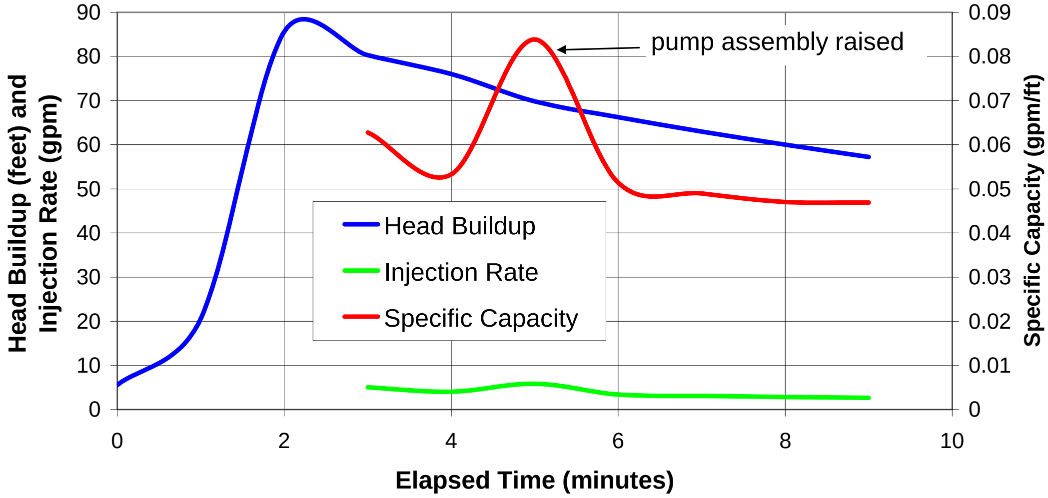

Figure F-4.4-1 Head buildup following packer deflation

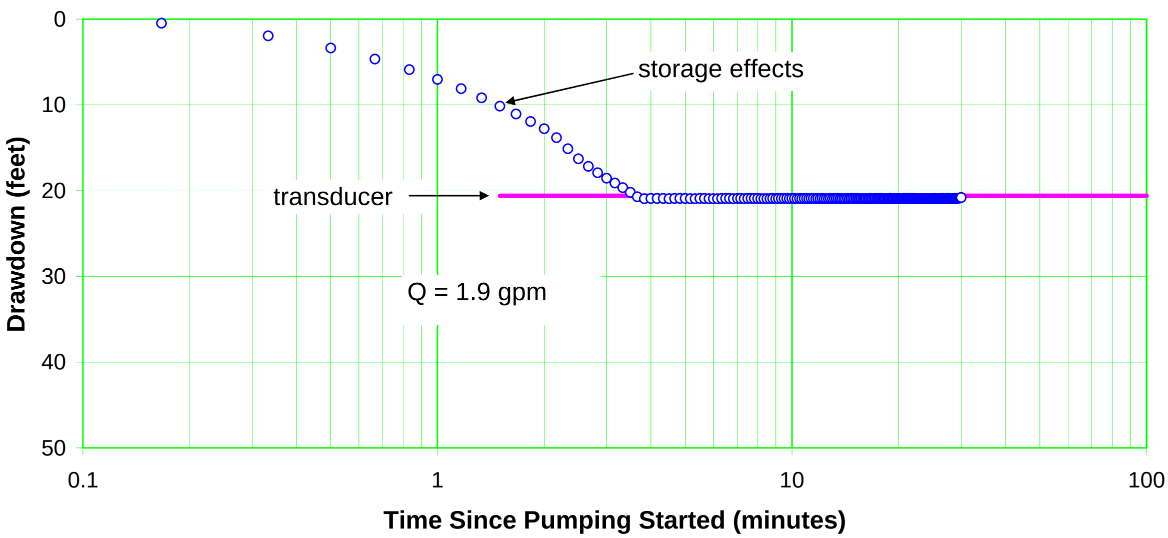

Figure F-4.5-1 Well R-39 second drop pipe fill drawdown

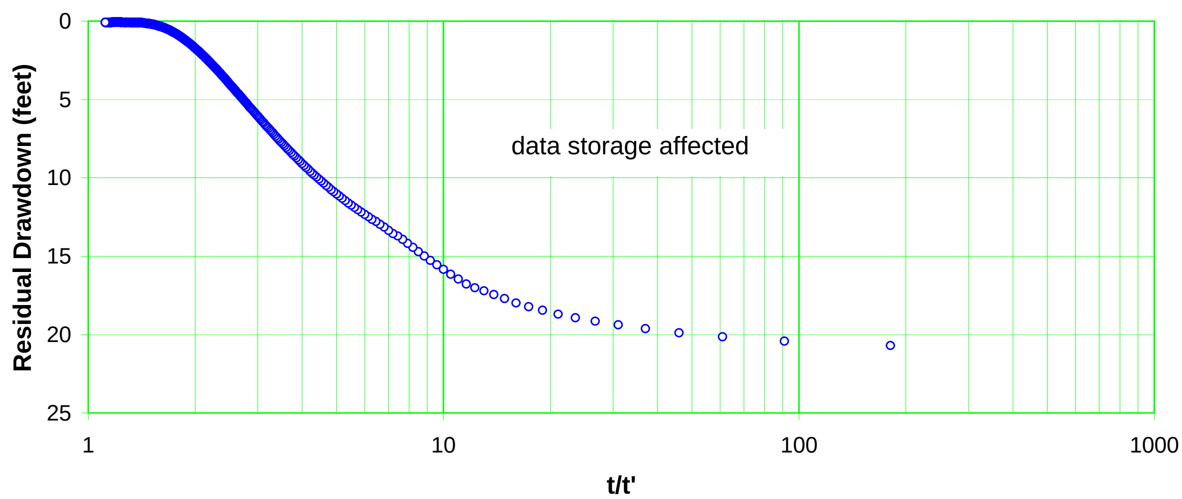

Figure F-4.5-2 Well R-39 second drop pipe fill recovery

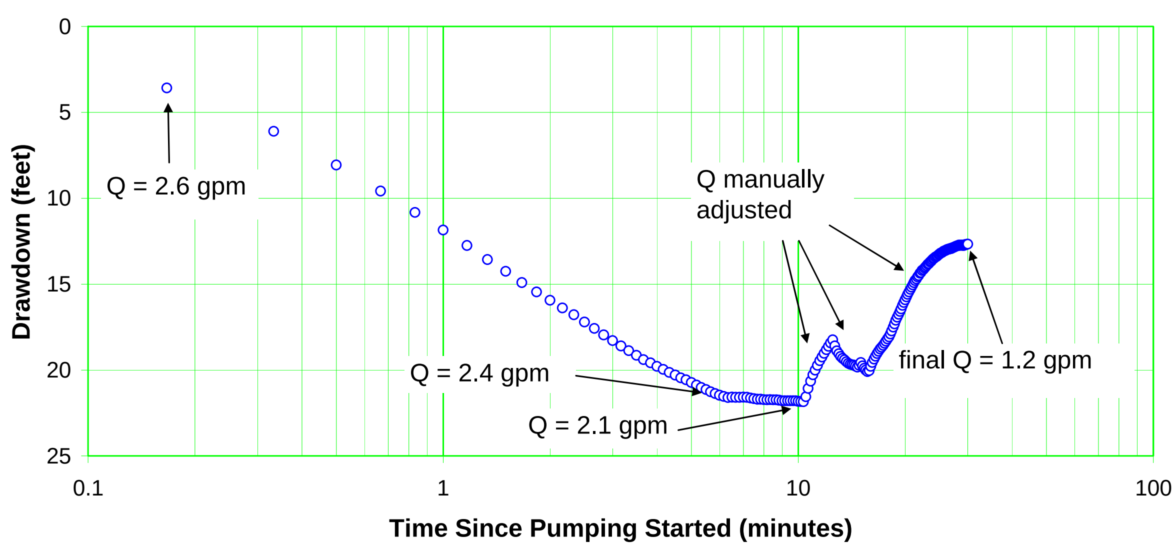

Figure F-4.6-1 Well R-39 trial 3 drawdown

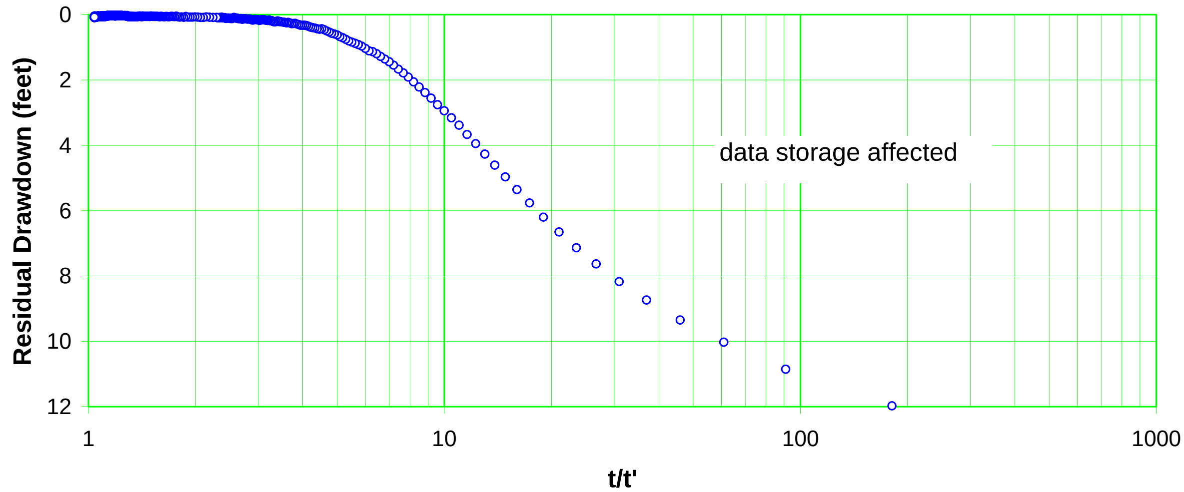

Figure F-4.6-2 Well R-39 trial 3 recovery

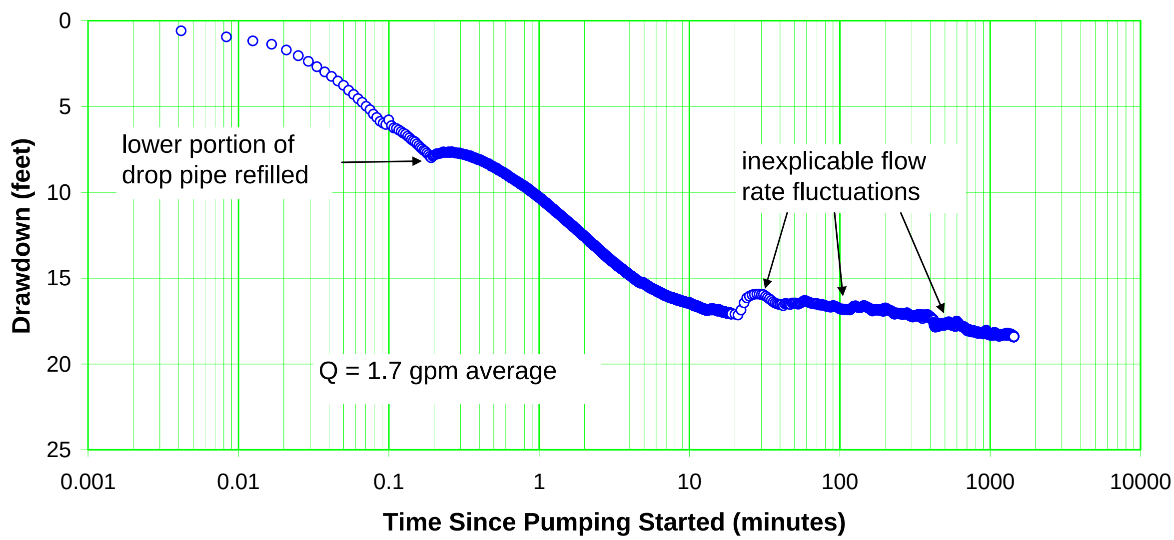

Figure F-4.7-1 Well R-39 drawdown

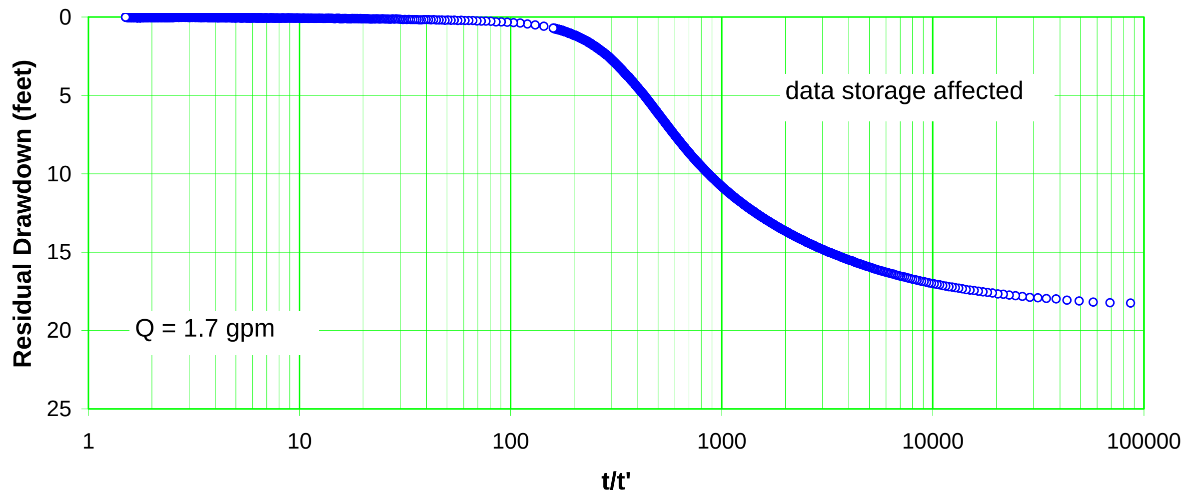

Figure F-4.7-2 Well R-39 recovery

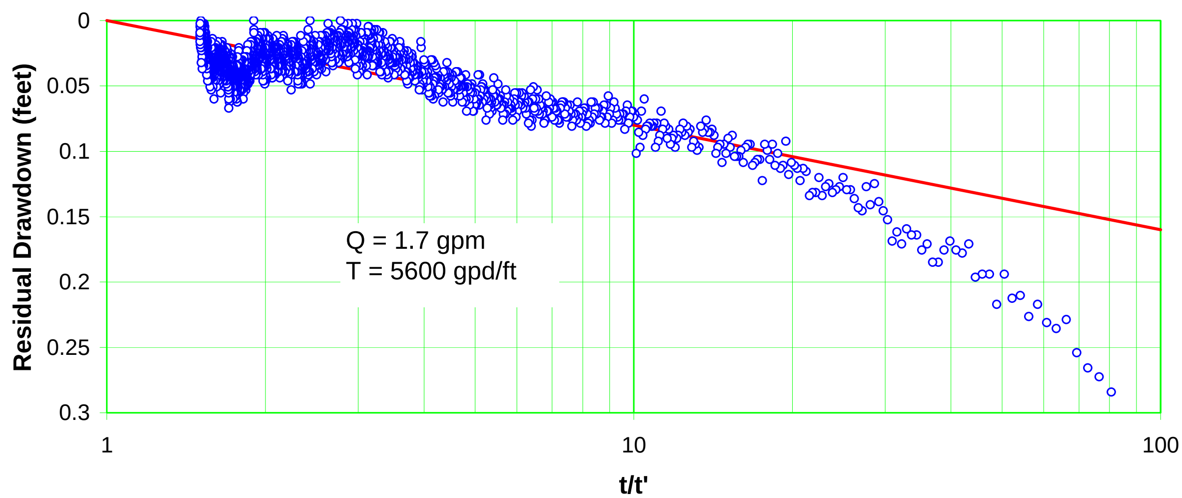

Figure F-4.7-3 Well R-39 recovery—expanded scale

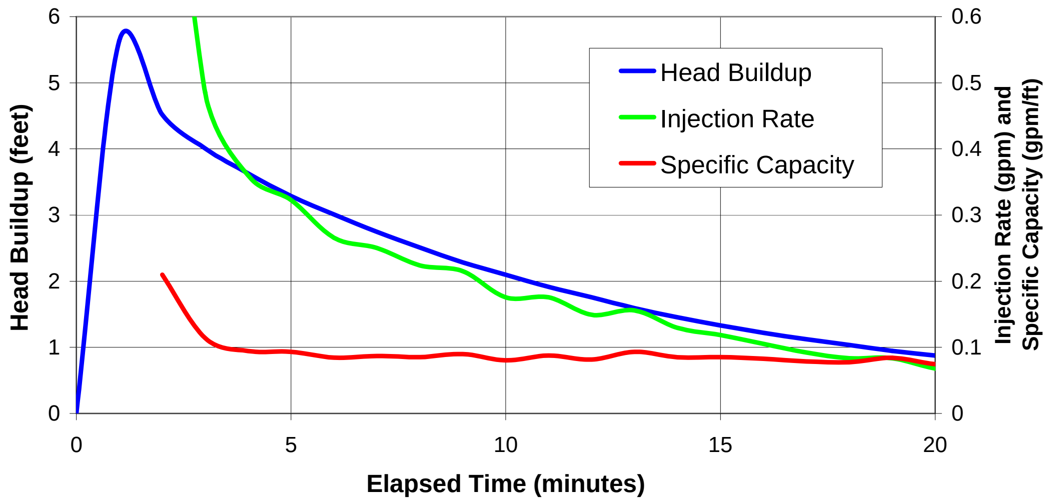

Figure F-4.8-1 Head buildup following final packer deflation

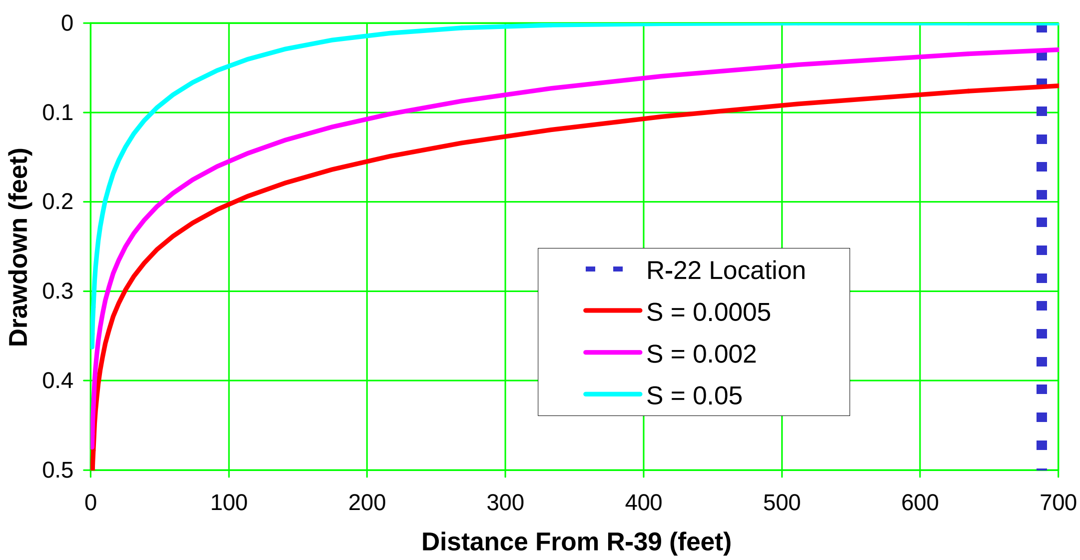

Figure F-4.10-1 Theoretic drawdown pumping R-39 at 1.7 gpm for 1 day with T = 5600 gpd/ft

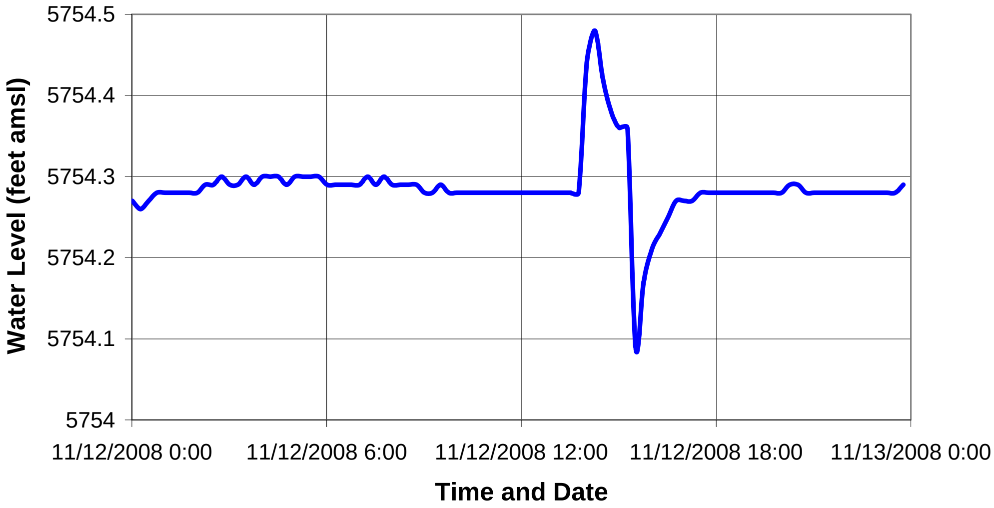

Figure F-4.10-2 R-22 screen 2 observed water levels on November 12, 2008

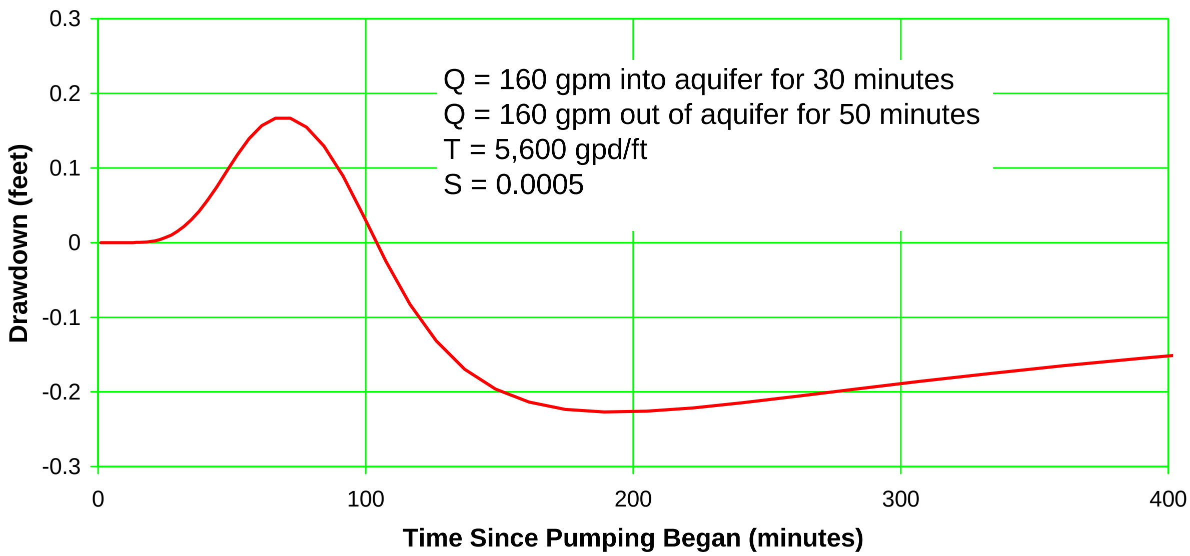

Figure F-4.10-3 Simulated pressure response in R-22–long stress periods

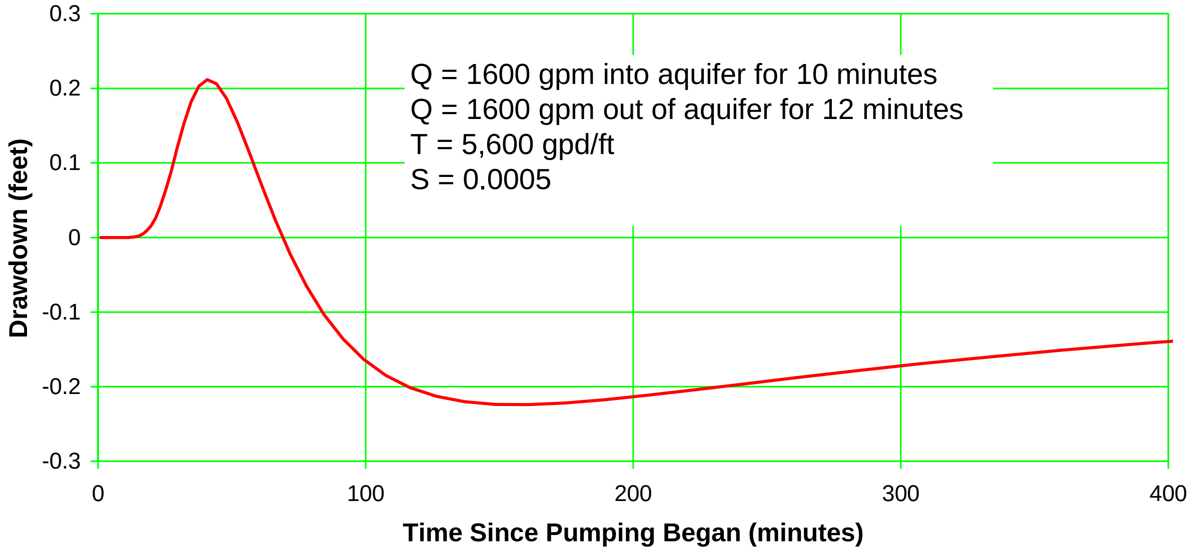

Figure F-4.10-4 Simulated pressure response in R-22-short stress periods