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Completion Report for Intermediate Aquifer Well PCI-2

Los Alamos
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Prepared by the Environmental Programs Directorate

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EXECUTIVE SUMMARY

This well completion report describes the drilling, installation, and development of Los Alamos National Laboratory's intermediate PCI-2 monitoring well and a collocated shallow PCI-2 core hole. Both are located in Pajarito Canyon, immediately below the flood retention structure built after the Cerro Grande fire in Technical Area 15 (TA-15) in Los Alamos County, New Mexico. This report was written in accordance with the requirements in Section IV.A.3.e.iv of the March 1, 2005, Compliance Order on Consent. The well was installed at the direction of the New Mexico Environment Department (NMED) to monitor perched intermediate-depth groundwater that was encountered during the drilling of adjacent regional well R-17 in December 2005. The core hole's objective was to evaluate the reproducibility of the elevated tritium concentrations in analytical samples obtained from the R-17 core hole.

The PCI-2 monitoring well borehole was drilled using dual-rotary air-drilling methods. Fluid additives used included potable water and foam. Foam-assisted drilling was used only above the anticipated perched water zone; no drilling-fluid additives other than small amounts of potable water were used below 392.0 ft below ground surface (bgs), roughly 100 ft above the targeted zone. Additive-free drilling provides minimal impacts to the groundwater and aquifer materials. The PCI-2 borehole was successfully completed to total depth (TD) using dual-rotary casing-advance drilling methods.

During drilling, a retractable 16-in. casing was advanced through the upper portion of the Bandelier Tuff to a depth of 292.9 ft bgs in the Otowi Member of the Bandelier Tuff. A retractable 12-in. casing was then advanced to a TD of 566.0 ft bgs. The PCI-2 monitoring well was completed with a single screen to evaluate water quality and measure water levels in a perched aquifer within the upper portion of the Puye Formation stratigraphically above an extensive dacitic lava horizon. The 10-ft long screened interval has the top of the screen set at 512.0 ft bgs.

The well was completed in accordance with an NMED-approved well design. Well development activities indicated that monitoring well PCI-2 is poorly productive but will likely perform effectively to meet the planned objectives. A water-level transducer was placed in the screened interval in the PCI-2 well, and groundwater sampling will be performed as part of the facility-wide groundwater-monitoring program.

The PCI-2 core hole was continuously cored using hollow-stem augers from 23.0 to 163.0 ft bgs, with multiple analytical samples collected from the recovered core. No groundwater was detected during coring, and the core hole was subsequently plugged and abandoned in accordance with NMED requirements.

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Acronyms and Abbreviations

μS/cm	microsiemens per centimeter
amsl	above mean sea level
AK	acceptable knowledge
ASTM	American Society for Testing and Materials
bgs	below ground surface
Consent Order	Compliance Order on Consent
DO	dissolved oxygen
DTW	depth-to-water
EES-14	Earth and Environmental Sciences Group
EP	Environmental Programs
EPA	Environmental Protection Agency (U.S.)
HAS	hollow-stem auger
IC	ion chromatography
ICPMS	inductively coupled plasma mass spectrometry
ICPOES	inductively coupled plasma optical emission spectroscopy
ID	identification
I.D.	inside diameter
LANL	Los Alamos National Laboratory
mV	millivolt
NMED	New Mexico Environment Department
NTU	nephelometric turbidity unit
O.D.	outside diameter
ORP	oxidation-reduction potential
PVC	polyvinyl chloride
Qal	Quaternary Alluvium
Qbo	Quaternary Otowi Member of the Bandelier Tuff
Qbog	Quaternary Guaje Pumice Bed of Otowi Member of the Bandelier Tuff
Qbt 1g	Quaternary unit 1g of Tshirege Member of the Bandelier Tuff
Qbt 1v	Quaternary unit 1v of Tshirege Member of the Bandelier Tuff
Qbt 2	Quaternary unit 2 of Tshirege Member of the Bandelier Tuff
Qct	Cerro Toledo Interval
RPF	Records Processing Facility
SOP	standard operating procedure

TA	technical area
Tb 2	Tertiary dacite lava
Tb 4	Tertiary Cerros del Rio basalt
TD	total depth
TOC	total organic carbon
Tpf	Tertiary Puye Formation
Tp 2	Tertiary dacitic lava
Tt2	dacitic lava
VOC	volatile organic compound
WCSF	waste characterization strategy form
wt%	weight percent

1.0 INTRODUCTION

This completion report summarizes site preparation, borehole drilling, well construction, well development, and dedicated sampling system installation for intermediate-perched groundwater monitoring well PCI-2 and a collocated shallow core hole. The report is written in accordance with the requirements in Section IV.A.3.e.iv of the March 1, 2005, Compliance Order on Consent (the Consent Order). The PCI-2 monitoring well borehole was drilled from March 13 to 23, 2009, and completed from March 31 to April 10, 2009, while the PCI-2 core hole was drilled and abandoned between March 28 and April 21 at Los Alamos National Laboratory (LANL or the Laboratory) for the LANL Water Stewardship Program.

The PCI-2 project site is located in Technical Area 15 (TA-15) in Pajarito Canyon, Los Alamos County, New Mexico, immediately below the flood retention structure built after the Cerro Grande fire (Figure 1.0-1). Both PCI-2 boreholes share the existing R-17 regional well drill pad and are located upcanyon from R-17. The purpose of the PCI-2 well is to monitor perched-intermediate groundwater that was encountered during the drilling of R-17 in December 2005. The PCI-2 core hole's purpose was to evaluate the reproducibility of the elevated tritium concentration results obtained from the R-17 core hole. The PCI-2 core hole was abandoned after successful core collection.

The primary objective of the drilling activities at PCI-2 was to drill and install a single-screen intermediate depth perched aquifer monitoring well. Secondary objectives were to collect drill-cutting samples, collect borehole geophysical data, and sample potential perched groundwater zones, as well as to obtain multiple, depth-specific analytical core samples.

The PCI-2 borehole was drilled to a total depth (TD) of 566.0 ft below ground surface (bgs). A monitoring well was then installed with one 10-ft screen between 512.0 and 522.0 ft bgs. The depth-to-water (DTW) after well installation was 508.8 ft bgs on April 11, 2009. During drilling, cuttings samples were collected at 5-ft intervals in the borehole from ground surface to TD. For the core hole, coring was continuous from 23.0 to 163.0 ft bgs, with a total of 33 analytical samples collected from the recovered core.

Postinstallation activities included well development, surface completion, geodetic surveying, and installation of a dedicated sampling system. Future activities include site restoration and waste management.

The information presented in this report was compiled from field reports and daily activity summaries. Records, including field reports, field logs, and survey information, are on file at the Laboratory's Records Processing Facility (RPF). This report contains brief descriptions of activities and supporting figures, tables, and appendixes completed to date associated with the PCI-2 project. Information on radioactive materials and radionuclides, including the results of sampling and analysis of radioactive constituents, is voluntarily provided to the NMED in accordance with U.S. Department of Energy policy.

2.0 PRELIMINARY ACTIVITIES

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

2.1 Administrative Preparation

The following documents helped guide the implementation of the scope of work for the PCI-2 project: "Drilling Plan for Intermediate Well PCI-2 and PCI-2 Core hole," (TerranearPMC 2009, 106320); "Integrated Work Document for Regional and Intermediate Aquifer Well Drilling (Mobilization, Site Preparation and Setup Stages)" (LANL 2007, 100972); "Storm Water Pollution Prevention Plan for SWMUs and AOCs (Sites) and Storm Water Monitoring Plan" (LANL 2006, 092600); and "Waste Characterization Strategy Form for the R-38, R-41, R-44, and R-46 Regional Groundwater Well Installation and Corehole Drilling" (LANL 2008, 103916).

2.2 Site Preparation

Minor site preparation was performed by Laboratory personnel to the existing R-17 drill site before rig mobilization. On March 13, activities included moving the dual-rotary drill rig, air compressors, trailers, and support vehicles to the drill site and staging alternative drilling tools and construction materials at the Pajarito Road laydown yard. The auger drilling rig for the PCI-2 core hole was brought on-site later on April 14.

Potable water was obtained from a Pajarito Road fire hydrant at TA-18 and as a backup at a fire hydrant on Puye Road. Safety barriers and signs were installed around the borehole cuttings containment pit and along the perimeter of the work area.

3.0 DRILLING ACTIVITIES

This section describes the drilling strategy and approach and provides a chronological summary of field activities conducted at both the monitoring well PCI-2 and PCI-2 core hole.

3.1 Drilling Approach

The drilling methodology and selection of equipment and drill-casing sizes for the PCI-2 monitoring well were designed to retain the ability to investigate and case off perched groundwater above the target perched water zone (encountered while drilling adjacent R-17). Further, the drilling approach ensured that a sufficiently sized drill casing was used to meet the required 2-in. minimum annular thickness of the filter pack around a 5.56-in.-outside diameter (O.D.) well.

Dual-rotary air-drilling methods using a Foremost DR-24HD drill rig were employed to drill the PCI-2 borehole. Dual-rotary drilling has the advantage of simultaneously advancing and casing the borehole. The Foremost DR-24HD drill rig was equipped with conventional drilling rods, tricone bits, downhole hammer bits, a deck-mounted 900 ft^3/min air compressor, and general drilling equipment. Auxiliary equipment included two Sullair 1150 ft^3/min trailer-mounted air compressors. Two sizes of A53 grade B flush-welded mild carbon-steel casing (16-in. and 12-in. inside diameter [I.D.]) were used for the PCI-2 project. The dual-rotary technique at PCI-2 used filtered compressed air and fluid-assisted air to evacuate cuttings from the borehole during drilling. Cuttings samples were collected at 5-ft intervals in the borehole from ground surface to TD to characterize the hydrostratigraphy of rock units encountered in the borehole.

Drilling fluids, other than air, used in the borehole (all within the vadose zone) included municipal water and a mixture of municipal water with Baroid AQF-2 foaming agent. The fluids were used to cool the bit and help lift cuttings from the borehole. Use of foaming agents was terminated at 392.0 ft bgs, roughly 100 ft above the expected perched groundwater horizon. No additives other than municipal water were used for drilling below this depth (392.0 ft bgs). Total amounts of drilling fluids introduced into the borehole and those recovered are recorded and presented in Table 3.1-1.

For the PCI-2 core hole, a CME 75 auger rig, equipped with 4.25-in.- × 9-in.-O.D. hollow-stem augers (HSAs) and a split core barrel, was selected to adequately meet the depth and sampling requirement of this portion of the PCI-2 project. No fluids were utilized during auger drilling, and subsequent abandonment practices and materials met NMED requirements.

3.2 Chronological Drilling Activities for the PCI-2 Well

Mobilization of drilling equipment and supplies to the PCI-2 drill site occurred on March 13, 2009. Decontamination of the equipment and tooling was performed before mobilization to the site. Following on-site equipment inspections, the monitoring well borehole was initiated on March 14 at midday (1315 h) using dual-rotary methods with 16-in. drill casing and a 15-in. (14.75-in.) tricone bit. Drilling and advancing 16-in. casing proceeded rapidly through canyon bottom alluvium and the lowermost unit of the Tshirege Member of the Bandelier Tuff to a depth of 139.5 ft bgs, where the driller detected possible groundwater within the Cerro Toledo interval. A water sample was collected, the casing lifted 3 ft, and the borehole left open overnight. The next day (March 15), a small amount of water was observed at TD and a water level of 139.3 ft bgs was measured. A second water sample was taken and drilling resumed.

Drilling continued to a depth 233.0 ft bgs where the driller again indicated possible groundwater at 232–233 ft bgs in the Otowi Member (of the Bandelier Tuff). The water appeared to be associated with several feet of formation heave in the borehole. A depth to water of 189.0 ft bgs was measured. Air-only circulation indicated an initial water flow rate of 10–15 gpm, diminishing to 3–5 gpm in about 8 min. A water sample was taken and drilling again resumed. Water flow of 1 gpm or less was noted at 253.0 ft bgs (at 1740 h, March 15) but increased to an estimated 5–10 gpm in 10 min. A seemingly stable DTW of 207.4 ft bgs was measured in the morning of the next day. An estimated flow rate of 3–5 gpm occurred upon air-only circulation start-up and a water sample was taken. Only limited water-flow rates (<1 gpm) were observed while drilling to a depth of about 272 ft bgs, which was thought to be the base of the water-producing zone in the Otowi Member. Drilling continued without further groundwater indications to 292.9 ft bgs, where the 16-in. drill casing was landed on March 16. Laboratory personnel ran a natural gamma-ray log after the drilling tools were tripped out of the borehole that day.

On March 17, the 16-in. casing was cut at 286.2 ft bgs and 7 linear feet (10.0 ft^3) of bentonite was placed to form a bottom-hole seal for the shallow perched water zone(s) previously drilled through. A string of 12-in. drill casing was also started into the borehole that day. Drilling using dual-rotary methods with the 12-in. casing string and a 12-in. (11.62-in.) tricone bit started the morning of March 19 at 278.4 ft bgs. The next day (midafternoon, March 20), the driller thought that groundwater might be present around 470 ft bgs. A water-flow rate of about 2 gpm was estimated at a drill depth of 490.0 ft bgs in the Guaje Pumice Bed, which quickly diminished. A water sample from this zone was taken. Drilling progressed into the upper Puye Formation and was accompanied by minor bit-plugging problems and lost circulation. An estimated water flow of 2 gpm was noted (and sampled) at 510 ft bgs at the end of the day on March 20.

The next day, March 21, DTW was measured at 504.6 ft bgs, a sample was taken from a measured 0.75 gpm water flow, and the 12-in. casing retracted 20.4 ft (to 491.3 ft bgs) in preparation for video logging. The camera (Laboratory equipment) showed water in the borehole at 504.8 ft bgs, and the decision was made to drill an additional 20 ft. By midday on March 22, TD was 532.2 ft bgs, and drilling was suspended to monitor water levels. After 2 h, the DTW was recorded at 531.1 ft bgs, and then the 12-in. casing was retracted 7 ft (to 525.2 ft bgs) to better allow water to enter the borehole.

In the morning of March 23, DTW was below the bit depth of 525.4 ft bgs; the measurement was done inside drill string. By midmorning, the decision was made to continue drilling to the top of the dacitic lava flow, estimated to be encountered roughly 30 ft deeper. The borehole's ultimate TD of 566.0 ft was reached by day's end (at 1640 h) with only minimal groundwater indications observed while drilling the final footage.

A DTW of 562.2 ft bgs was measured the next day (March 24) as preparations were made to cut off the 12-in. casing shoe. A quick check with the Laboratory's video logging tool verified a clean cut in the 12-in. casing at 560.0 ft bgs. After tripping out the video camera, the 12-in. casing was retracted 74.2 to 485.8 ft bgs, and a water level of 537.5 ft bgs was recorded.

A 536.5 ft bgs, water level was recorded the morning of March 25 immediately before running the Laboratory video, natural gamma-ray, and induction tools in the borehole. The video revealed water flowing into the borehole at approximately 510 ft bgs and the flow increasing with depth. To evaluate the inflow, a plan was formulated to seal the bottom of the borehole with bentonite chips capped by 2 ft of 10/20 silica sand to a depth of 533.5 ft bgs, bail a small amount of water (approximately 30 gal.), and monitor the resulting water level. After bailing, by midmorning on March 31 the water level had risen to 505.7 ft bgs and preparations were started for well construction.

During drilling, field crews worked a single 12-h shift each day, 7 d/wk. All associated daily activities proceeded normally without incident or delay.

3.3 Chronological Drilling and Abandonment Activities for the PCI-2 Core Hole

Late March 28, 2009, afternoon after moving off of the PCI-2 borehole, the dual-rotary drilling rig was used to advance and land a 10-in. surface casing for the core hole through the alluvium to 20.4 ft bgs. The core hole, similar to the PCI-2 monitoring well, shared the regional well R-17 drill pad.

A CME 75 auger drilling rig was moved onto the drill site on April 14. The rig was equipped with HSAs measuring 4.25-in.-I.D. × 9-in.-O.D. and a 3.5-in. × 5.0-ft split-barrel core sampler. The split-barrel core sampler was run in the HSAs on 5-ft solid core hex rods. All downhole tools were decontaminated on-site that day.

Drilling started at 18.9 ft bgs inside the 10-in. surface casing at 1550 h on April 14; coring began at 23.0 ft bgs shortly thereafter. Continuous coring progressed smoothly per plan to a TD of 163.0 ft bgs, which was reached on April 16 (1545 h) in the upper portion of Otowi Member of the Bandelier Tuff. Several stops were made to check for water in the borehole while drilling, at 32.5, 119.0, and 159.0 ft bgs, and the hole was found to be dry at all depths. After reaching TD, the augers were retracted to 137.5 ft bgs. On April 17, Laboratory personnel ran a video survey in the open portion of the borehole verifying that no water was present, including in the thin interval (at about 139.5 ft bgs) where groundwater was detected in the R-17 monitoring well borehole.

As per the drilling plan and as a consequence of the lack of perched water in the borehole, abandonment was conducted on April 17. Abandonment consisted of cleaning out the borehole to 163.0 ft bgs (TD) and continuously backfilling with 49.6 ft^3 of hydrated 0.375-in. bentonite chips from 161.5 to 22.5 ft bgs as the augers were removed from the hole. The auger rig was unable to pull the 10-in. surface casing and was moved off of the borehole on April 20. A Pulstar work-over rig was brought on-site and easily removed the casing that day. Neat Portland cement with 1 weight percent (wt%) Baroid IDP-381 retardant was placed in the borehole, capping the bentonite to ground surface on April 21 (cement volume, 13.4 ft^3). A small amount of additional cement mix was added several days later because of minor settlement.

During core hole drilling, field crews worked a single 12-h shift each day, 7 d/wk. All associated daily activities proceeded normally without incident or delay.

4.0 SAMPLING ACTIVITIES

This section describes the cuttings and groundwater sampling activities for monitoring well PCI-2 and core sampling for the PCI-2 core hole. All sampling activities were conducted in accordance with applicable quality procedures.

4.1 Cuttings Sampling

Cuttings samples were collected from the PCI-2 monitoring well borehole at 5-ft intervals from ground surface to the TD of 566.0 ft bgs. At each interval, approximately 500 mL of bulk cuttings was collected by the site geologist from the drilling cyclone discharge, placed in resealable plastic bags, labeled, and archived in core boxes. Sieved fractions (>#10 and >#35 mesh) were also collected from ground surface to TD and placed in chip trays along with unsieved (whole rock) cuttings. Recovery of the cuttings samples was 100% of the borehole. Radiation control technicians screened cuttings before removal from the site. All screening measurements were within the range of background values. The core boxes and chip trays were delivered to the Laboratory's archive at the conclusion of drilling activities.

The borehole lithologic log for PCI-2 stratigraphy is summarized in section 5.1 and detailed in Appendix A.

4.2 Water Sampling

Groundwater-screening samples were collected from the drilling discharge hose starting at 139.5 ft bgs to evaluate potential perched groundwater zones and continued through the borehole's TD of 566.0 ft bgs. Typically, upon reaching the bottom of a 20-ft run of casing, the driller would stop water circulation (if injecting water) and circulate air. As the discharge cleared, a water sample was collected directly from the discharge cyclone. Table 4.2-1 presents a summary of screening samples collected at the PCI-2 monitoring well.

Nine groundwater screening samples, from depths of 139.5 to 510.0 ft bgs, were collected from the monitoring well borehole during drilling operations by air-lifting water samples through the drill string. All of these samples represented waters collected while drilling through the vadose zone to evaluate the presence or absence of perched groundwater. These screening samples were analyzed for tritium, and a sample collected at the TD of the borehole was analyzed for anions and metals.

Three groundwater-screening samples were collected during well development from the development pump's discharge line. Development screening samples were analyzed for anions, metals, and total organic carbon (TOC).

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

4.3 Core Sampling

Core recovery from the PCI-2 core hole was typically good and averaged 85% overall. From the recovered core, 33 analytical samples were collected from the following 11 depth intervals: 23.0–24.5, 30.5–32.5, 37.5–40.0, 52.5–54.0, 62.5–64.0, 82.5–84.0, 92.5–94.0, 100.0–101.3, 120.0–121.3, 139.5–141.0, and 161.5–163.0 ft bgs, in accordance with the sampling plan. All core was obtained using Lexan sleeves in the core barrel, and all analytical samples were moisture-wrapped in heat-sealed foil when taken. Details of the core sampling are presented in Table 4.3-1 and in the core hole log in Appendix A. Recovered sections of the core not sampled were archived in core boxes and delivered to the Laboratory's archive at the conclusion of drilling activities. Similar to the cuttings samples, all radiation screening measurements were within the range of background values.

5.0 GEOLOGY AND HYDROGEOLOGY

A brief description of the geologic and hydrogeologic features encountered at the PCI-2 monitoring well is presented below. The PCI-2 core hole, because of proximity to the PCI-2 well, shares the same near-surface stratigraphy. The Laboratory's geology task leader and site geologists examined cuttings and geophysical logs to determine geologic contacts and hydrogeologic conditions. Drilling observations, video logging, water-level measurements, and geophysical logs were used to characterize groundwater occurrences encountered at the PCI-2 well.

5.1 Stratigraphy

The stratigraphy observed in the PCI-2 borehole is described below in order of youngest to oldest geologic units. Unit descriptions are based on drill cuttings samples collected from the discharge hose. Cuttings, borehole video, and geophysical logs were used to identify geologic contacts. Figure 5.1-1 illustrates the stratigraphy at PCI-2. A detailed lithologic log based on microscopic examination and analysis of drill cuttings is presented in Appendix A.

Alluvium (0–33 ft bgs)

Alluvial sediments were encountered at PCI-2 from ground surface to 33 ft bgs. These tuffaceous sediments are made up of unconsolidated, silty, fine to coarse sand with pebble gravel containing detrital materials derived from the Bandelier Tuff and other volcanic rocks. No evidence of alluvial groundwater was observed.

Unit 1g of the Tshirege Member of the Bandelier Tuff, Qbt 1g (33–131 ft bgs)

Unit 1g of the Tshirege Member of the Bandelier Tuff was encountered from 33 to 131 ft bgs, as interpreted from cuttings and natural gamma-ray geophysical log data. Unit 1g is a vitric, poorly welded ash-flow tuff that is strongly pumiceous, crystal-bearing, and lithic-poor, with a matrix of weathered to vitric ash. Unit 1g cuttings commonly exhibit pale orange to white glassy, quartz- and sanidine-phyric pumice lapilli, small (less than 10 mm in diameter) subangular volcanic lithic fragments (predominantly dacite), free quartz and sanidine crystals, and locally abundant orange-tan vitric ash. Intact fragments of unit 1g tuff are generally not observed in cuttings.

Cerro Toledo Interval, Qct (131–156 ft bgs)

The Cerro Toledo interval, intersected from 131 to 156 ft bgs (as interpreted from cuttings and natural gamma-ray logging data), is estimated to be 25 ft thick at PCI-2. This unit, consisting of poorly consolidated sediments derived from local tuffaceous and other volcanic sources, stratigraphically separates the Tshirege and Otowi Members of the Bandelier Tuff. The Cerro Toledo interval locally consists of weakly consolidated, silty, fine to coarse sands and gravels made up of detrital tuffaceous and volcanic materials (predominantly hornblende-bearing and other varieties of dacite), weathered to glassy pumice fragments, and abundant quartz and sanidine crystal grains.

Otowi Member of the Bandelier Tuff, Qbo (156–484 ft bgs)

The Otowi Member of the Bandelier Tuff, encountered in PCI-2 from 156 to 484 ft bgs, is 328 ft thick as interpreted from cuttings and natural gamma-ray geophysical log data. The Otowi Member is a poorly welded, pumiceous, locally lithic-rich, crystal-bearing ash-flow tuff. It locally contains abundant white to pale orange, glassy pumice lapilli (fiberous-textured and quartz- and sanidine-phyric), volcanic lithic fragments (i.e., xenoliths) and moderately abundant quartz and sanidine crystals enclosed in a matrix of vitric ash. Locally abundant subangular lithic fragments (up to 20 mm in diameter) are predominantly of intermediate volcanic compositions that include gray to pinkish gray hornblende- and/or biotite-phyric dacites, andesite, and some obsidian. Intact fragments of Otowi Member tuff are seldom present in drill cuttings.

Guaje Pumice Bed of the Otowi Member of the Bandelier Tuff, Qbog (484–498 ft bgs)

The Guaje Pumice Bed occurs in PCI-2 from 484 to 498 ft bgs on the basis of cuttings and natural gamma-ray log interpretation and is estimated to be 14 ft thick. This tuff unit is commonly characterized by a predominance of white vitric, phenocryst-poor pumice lapilli. Cuttings suggest that the Guaje tuff unit is pumiceous, lithic-rich, and crystal-bearing. Abundant subangular to rounded dacitic lithics, quartz and sanidine phenocrysts, and fine ash are present.

Puye Formation, Tpf (498–557 ft bgs)

A 59-ft-thick section of Puye Formation volcaniclastic sediments was encountered in PCI-2 from 498 to 557 ft bgs. The Puye is locally composed of texturally diverse, gray, grayish-brown and pinkish-tan poorly sorted, fine to coarse gravels, gravelly, and silty sandstones with gravel. Significant intervals of silt-rich sediments were observed in drill cuttings intermittently throughout the section. Compositionally, the Puye Formation section is uniform throughout. Detrital constituents making up these sediments are generally subangular and predominantly of gray porphyritic hornblende-phyric dacites, dacitic vitrophyre, and lesser andesite.

Dacitic Lava, Tt2 (557–566 ft bgs)

Dacitic lava and possible dacite-rich sediments were intersected in the short interval from 557 to TD at 566 ft bgs. Cuttings in this section are of mixed broken chips and subangular clasts composed of vesicular to scoriaceous and massive pyroxene-phyric dacite. Lava fragments exhibit phenocryst–poor textures with phenocrysts (up to 1% by volume) of black opaque clinopyroxene and amber-colored orthopyroxene, commonly in cumulophyric clusters, set in a dark gray aphanitic groundmass.

5.2 Groundwater

Possible perched groundwater was first encountered in well PCI-2 at approximately 139.5 ft bgs in the Cerro Toledo interval on March 14, 2009. The next indication of possible perched water was detected at 232–233 ft bgs in the Otowi Member tuff and again at 253.0 ft bgs. All three of these zones exhibited variable (driller estimated) water-flow rates peaking in the 5 to 10 gpm range. A fourth indication of perched water was noted at about 272 ft bgs and had a flow rate of <1 gpm. All of the zones except the 272 ft bgs zone were sampled via air-lifting when penetrated. The 272 ft bgs zone did not produce enough water to generate a good quality sample.

Drilling continued without additional groundwater indications until 490 ft bgs in the Guaje Pumice Bed and shortly thereafter at 510 ft bgs in the upper portion of the Puye Formation. Both zones exhibited water-flow rates of 2 gpm or less and both were sampled.

Minimal water indications were observed while drilling deeper to TD (566.0 ft bgs), the top of a dacitic lava flow. Subsequent video logging revealed water entering the borehole at approximately 510 ft bgs after retracting the 12-in. casing 74.2 ft (bottom of 12-in. casing at 485.8 ft bgs). Measured water levels indicated a somewhat stabilized DTW of 505.7 ft bgs on March 28, 2009.

Procedurally, when sampling a suspected perched water zone, the driller would stop water circulation (if injecting water) and circulate air. As the discharge cleared, a water sample would be collected directly from the discharge hose. Groundwater-screening samples collected during drilling (and well development) are discussed in section 4.2 and presented in Table 4.2-1. Groundwater chemistry and field water-quality parameters are discussed in Appendix B.

No groundwater was observed during coring operations or at TD (163.0 ft bgs) in the PCI-2 core hole.

6.0 BOREHOLE LOGGING

Several video logs and a limited suite of geophysical logs were collected during the PCI-2 drilling project using Laboratory-owned equipment. A summary of video and geophysical logging runs is presented in Table 6.0-1.

6.1 Video Logging

Several video runs were made in the PCI-2 monitoring well as it was being drilled. The first occasion was on March 21, 2009, and showed water standing in the borehole at 504.8 ft bgs. A second run made on March 24 was used to verify a successful cut of the 12-in. drill casing at 560.0 ft bgs. The last video run (March 25) was made at final TD, 566.0 ft bgs, with the 12-in. drill casing that had been cut at 560.0 ft bgs retracted to 484.6 ft bgs. It showed water entering the open borehole at 510 ft bgs with inflow increasing with depth. The video also verified a water level at 536.5 ft bgs. The video logs are presented on DVD as part of Appendix C included with this document.

Laboratory personnel ran a video survey in the PCI-2 core hole by upon reaching TD (163.0 ft bgs), with the augers retracted 25.5 to 137.5 ft bgs on April 17, 2009. It confirmed that the boring was dry.

6.2 Geophysical Logging

A shallow, natural gamma-ray survey was run in the borehole on March 16, 2009, after the 16-in. casing string had been landed at 292.9 ft bgs. Final logging with both natural gamma-ray and induction tools occurred on March 25 after the 12-in. drill casing had been cut at 560.0 ft and retracted to 484.6 ft bgs. Laboratory equipment was used in both instances. Logging data are presented on CD as part of Appendix D and Table 6.0-1 details individual geophysical logging runs.

7.0 WELL INSTALLATION OF PCI-2 MONITORING WELL

The PCI-2 well was installed between March 31 and April 10, 2009.

7.1 Well Design

The PCI-2 well was designed in accordance with the Consent Order and approved by NMED before installation. A single screened interval design monitored perched groundwater quality and water levels in the upper part of the Puye Formation lying stratigraphically above a dacitic lava flow.

7.2 Well Construction

The PCI-2 monitoring well was constructed of 5.0-in.-I.D./5.56-in.-O.D. type A304 stainless-steel threaded casing, fabricated to American Society for Testing and Materials (ASTM) A312 standards. The screened section utilized one 10-ft length of 5.0-in.-I.D. rod-based 0.020-in. wire-wrapped well screen. Compatible external stainless-steel couplers (also type A304 stainless steel fabricated to ASTM A312 standards) were used to join all individual casing and screened sections. The coupled unions between threaded sections were approximately 0.7 ft long. The screen and all casing were steam- and pressure-washed on-site before installation. During well construction, 2 in.-I.D. steel threaded/coupled tremie pipe string (decontaminated before use) was utilized downhole for delivery of backfill and annular fill materials. The placement of annular and backfill materials had two components: installing the materials and retracting the drill casing coupled with raising the tremie pipe. As each section of drill casing was cut off the string, it was picked up and laid down. During this part of the process, the well casing was hung on a wireline while the drill casing was supported by a ring and slips. Short lengths of 12-in. (6.0-ft casing/shoe) and 16-in. (6.7-ft casing/shoe) drill casing remain in the borehole. The 12-in. casing stub was entombed in formation slough below bentonite backfill, while the 16-in. casing stub was set in bentonite.

The nominal 10-ft long screened interval had the top of the screen set at 512.0 ft bgs. An 11.3-ft stainless-steel sump was placed below the bottom of the well screen. Stainless-steel centralizers (two sets of four) were welded to the well casing approximately 2.0 ft above and below the screen. A Pulstar work-over rig was used for all well construction activities. Figure 7.2-1 presents an as-built schematic showing construction details for the completed well.

The Pulstar work-over rig was moved on location March 29, 2009; decontamination of the stainless-steel well casing and screen occurred the next day along with mobilization of initial well construction materials to the site.

On March 25, to evaluate water inflow, backfill consisting of 24.1 linear feet of 0.375-in. bentonite chips, capped by 3.2 linear feet of 10/20 silica sand, had been added to the borehole before well construction started and brought the borehole depth up to 533.5 ft bgs. On March 31 at 1140 h, the stainless-steel, 5-in. well casing was started into the wellbore. After landing the well casing at 533.3 ft bgs, the process of installation of annular materials began late in the day on April 2, 2009, when a lower seal composed of 0.375 in. bentonite chips (5.4 ft^3) was placed from 525.5 to 533.5 ft bgs.

A 10/20 silica sand filter pack was then installed from 506.5 to 525.5 ft bgs and surged to promote compaction (total 10/20 sand: 20.0 ft^3). A short 20/40 silica sand transition collar on top the filter pack was placed from 505.4 to 506.5 ft bgs (2.0 ft^3).

The well's upper bentonite seal (0.375 in. chips) was installed on April 3–April 8 from 74.9 to 505.4 ft bgs, using a total of 379.2 ft^3 of bentonite chips. The final surface seal, a mix of 98 wt% Portland cement with 2 wt% Baroid IDP-381 additive, was placed above the upper bentonite seal from 3.0 to 74.9 ft bgs. Baroid IDP-381 enhances the flow properties and bonding characteristics of Portland cement, which will serve to improve the surface seal's function. This marked formal NMED well construction completion on April 10, 2009 (at 1415 h). Table 7.2-1 itemizes volumes of all materials used during well construction.

Operationally, well construction proceeded smoothly, 12 h/d, 7 d/wk, from March 31 (well casing install) to April 10, 2009. Because of high winds on April 4, a Laboratory fire safety shutdown stopped work all day.

8.0 POSTINSTALLATION ACTIVITIES

Following well installation at PCI-2, the well was developed. Total groundwater purged during well development was 1858 gal. The wellhead and surface pad were constructed, a geodetic survey was performed, and a dedicated sampling system was installed. Site restoration activities will be completed following the final disposition of contained drill cuttings and groundwater, per the NMED-approved waste-decision trees.

8.1 Well Development

Well development was conducted between April 11 and 20, 2009. Initially, the screened interval was bailed and swabbed to remove formation fines in the filter pack and sump. Bailing and swabbing continued until water clarity visibly improved. Final development was accomplished using two different submersible pumps.

The swabbing tool employed was a 4.5-in.-O.D., 1-in.-thick nylon disc attached to a weighted steel rod. The tool was lowered by wireline and drawn repeatedly in both directions across the screened interval. After bailing and swabbing, a 5-hp pump and then a lower capacity 1.5-hp 4-in.-Grundfos submersible pump were installed in the well for the final stage of well development. The larger 5-hp pump evacuated water too rapidly for thorough well development and had to be cycled on and off to allow the well screen interval to recharge. The lower-rated pump was necessary because of the zone's low rate of recharge to avoid pumping the well dry. Even with the smaller pump at its lowest operational limit of 0.7 gpm, the well would draw down and dewater after 10 to 11 h of sustained pumping (approximately one full shift). Approximately 1858 gal. of groundwater was purged at PCI-2 during the 9 d of well development activities.

During the pumping stage of well development, turbidity, temperature, pH, dissolved oxygen (DO), oxidation-reduction potential (ORP), and specific conductance parameters were measured. In addition, water samples for TOC analysis were collected. The required values for TOC and turbidity to determine adequate well development are less than 2.0 ppm and less than 5 nephelometric turbidity units (NTUs), respectively. While TOC values were less than 1.0 ppm, turbidity at its lowest was 10.0 NTUs. Well development activities at PCI-2 were stopped at the end of the shift on the tenth day (after eight full shifts of pumping). More than twice the amount of time was used to conduct PCI-2 well development activities than is typically used to conduct Laboratory well monitoring. It was determined that continued pumping at PCI-2 at less than 1 gpm would not likely attain the 5 NTUs turbidity standard.

A discussion of water removed during well development, field water-quality parameters, and analytical results for samples collected during development is summarized in section 8.1.1 and detailed in Table B-1.2-1 of Appendix B.

8.1.1 Well Development Field Parameters

Field parameters were measured at well PCI-2 by collecting aliquots of groundwater from the discharge pipe without the use of a flow-through cell, allowing the samples to be exposed to the atmosphere. This condition probably resulted in a slight variation of field parameters during well development and the pumping test, most notably, temperature, pH, and DO. A further discussion of well development field parameters is presented in Appendix B.

Measurements of pH varied from 7.18 to 8.46, and temperature varied from 5.97°C to 28.56°C. Dissolved oxygen varied from 2.03 to 5.51 mg/L and ORP measurements varied from –21.8 to –157.0 millivolts (mV). Specific conductance ranged from 135 to 161 microsiemens per centimeter (μS/cm). Values of turbidity measured at PCI-2 ranged from 61.6 to 10.0 NTUs for the nonfiltered groundwater samples.

8.2 Aquifer Testing

Because of the low pumping and recharge rates observed during well development, no aquifer testing was conducted at PCI-2.

8.3 Dedicated Sampling System Installation

A dedicated sampling system composed of a pneumatic Bennett pump was installed in PCI-2 on June 9, 2009. The Bennett pump is Model 180-6 and hung in the well on a tube bundle that includes a Teflon water-discharge line. The pump intake is set just below the screen interval at a depth of 527.8 ft bgs. To measure water levels in the well, one 1-in.-I.D. schedule 80 polyvinyl chloride (PVC) pipe was installed with and banded to the Bennett pump tube bundle to set a dedicated transducer below the measured static water level. The PVC transducer tube is equipped with a 6-in.-section of 0.010-in. slot screen with a threaded end cap at the bottom of the tube. An In-Situ Level Troll 500 transducer was installed inside the PVC tube. The transducer is readily removable for manual water-level measurements.

Postinstallation construction and sampling system component installation details for PCI-2 monitoring well are presented in Figure 8.3-1a. Figure 8.3-1b presents technical notes.

8.4 Wellhead Completion

A reinforced concrete surface pad, 10 ft × 10 ft × 6 in. thick, was installed at the PCI-2 (monitoring well) wellhead. The pad will provide long-term structural integrity for the well. A brass survey pin was embedded in the northwest corner of the pad. A 10-in.-I.D. steel protective casing with a locking lid was installed around the stainless-steel well riser. The concrete pad was slightly elevated above the ground surface and crowned to promote runoff. Base coarse was graded around the edges of the pad. A total of four bollards, painted yellow for visibility, are set at the outside corners of the pad to protect the well from traffic. All of the four bollards are designed for easy removal to allow access to the well. Details of the wellhead completion are presented in Figure 8.3-1a.

8.5 Geodetic Survey

A New Mexico licensed professional land surveyor conducted a geodetic survey on June 9, 2009 (Tables 8.5-1 and 8.5-2). The survey data collected conforms 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. Survey points include ground-surface elevation near the concrete pad, the top of the brass pin in the concrete pad, the top of the well casing, the top of the protective casing for the PCI-2 monitoring well, and the location and ground-level elevation of the abandoned PCI-2 core hole.

8.6 Waste Management and Site Restoration

Waste generated from the PCI-2 project includes drilling fluids, purged groundwater, drill cuttings, decontamination water, and contact waste. A summary of the waste characterization samples collected from the PCI-2 well is presented in Table 8.6-1.

All waste streams produced during drilling and development activities were sampled in accordance with “Waste Characterization Strategy Form for the R-38, R-41, R-44, R-45, and R-46 Regional Groundwater Well Installation and Corehole Drillings” (LANL 2008, 103916).

Fluids produced during drilling and well development are expected to be land-applied after a review of associated analytical results per the waste characterization strategy form (WCSF) and the EP-Directorate Standard Operating Procedure (SOP) 010.0, Land Application of Groundwater. If it is determined that drilling fluids are nonhazardous but cannot meet the criterion for land application, the drilling fluids will be evaluated for treatment and disposal at one of the Laboratory’s six wastewater treatment facilities. If analytical data indicate that the drilling fluids are hazardous/nonradioactive or mixed low-level waste, the drilling fluids will be disposed of at an authorized facility.

Cuttings produced during drilling are anticipated to be land-applied after a review of associated analytical results per the WCSF and ENV-RCRA SOP-011.0, Land Application of Drill Cuttings. If the drill cuttings do not meet the criterion for land application, they will be disposed of at an authorized facility. Decontamination fluid used for cleaning the drill rig and equipment is containerized. The fluid waste was sampled and will be disposed of at an authorized facility. Characterization of contact waste will be based upon acceptable knowledge (AK), pending analyses of the waste samples collected from the drill cuttings, purge water, and decontamination fluid.

Site restoration activities will include removing drilling fluids and cuttings from the pit and managing the fluids and cuttings in accordance with SOP-010.06, removing the polyethylene liner, removing the containment area berms, and backfilling and regrading the containment area, as appropriate.

9.0 DEVIATIONS FROM PLANNED ACTIVITIES

The target water-quality parameter for turbidity of less than 5 NTUs was not met during well development activities at PCI-2. However, the alternate standard of stabilization of pH, temperature, conductivity, and a TOC level of less than 2.0 ppm was achieved. The lack of available groundwater and the inability to pump the well at higher discharge rates are considered to be the reasons for turbidity values remaining above 5 NTUs.

Otherwise, drilling, sampling, and well construction at PCI-2 were performed as specified in “Drilling Plan for Intermediate Well PCI-2 and PCI-2 Core Hole” (TerranearPMC 2009, 106320).

10.0 ACKNOWLEDGMENTS

Boart Longyear drilled and installed the PCI-2 monitoring well and drilled and abandoned PCI-2 core hole.

Patrick Longmire wrote Appendix B, Groundwater Analytical Results.

Laboratory personnel ran downhole video and geophysical logging equipment.

Terranear PMC provided oversight on all preparatory and field-related activities.

11.0 REFERENCES AND MAP DATA SOURCES

11.1 References

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

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

LANL (Los Alamos National Laboratory), March 2006. “Storm Water Pollution Prevention Plan for SWMUs and AOCs (Sites) and Storm Water Monitoring Plan,” Los Alamos National Laboratory document LA-UR-06-1840, Los Alamos, New Mexico. (LANL 2006, 092600)

LANL (Los Alamos National Laboratory), October 4, 2007. “Integrated Work Document for Regional and Intermediate Aquifer Well Drilling (Mobilization, Site Preparation and Setup Stages),” Los Alamos National Laboratory, Los Alamos, New Mexico. (LANL 2007, 100972)

LANL (Los Alamos National Laboratory), October 2008. “Waste Characterization Strategy Form for the R-38, R-41, R-44, R-45, and R-46 Regional Groundwater Well Installation and Corehole Drilling,” Los Alamos, New Mexico. (LANL 2008, 103916)

TerranearPMC, March 2009. “Drilling Plan for Intermediate Well PCI-2 and PCI-2 Corehole,” plan prepared for Los Alamos National Laboratory, Los Alamos, New Mexico. (TerranearPMC 2009, 106320)

11.2 Map Data Sources for PCI-2 Completion Report Location Map

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

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

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

Paved Road Arcs; Los Alamos National Laboratory, KSL Site Support Services, Planning, Locating and Mapping Section; January 6, 2004; as published January 4, 2008.

Dirt Road Arcs; Los Alamos National Laboratory, KSL Site Support Services, Planning, Locating and Mapping Section; January 6, 2004; as published January 4, 2008.

Structures; Los Alamos National Laboratory, KSL Site Support Services, Planning, Locating and Mapping Section; January 6, 2004; as published January 4, 2008.

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

Pajarito Flood Retention Structure location approximately traced from 2005 Los Alamos National Laboratory Orthophotography.

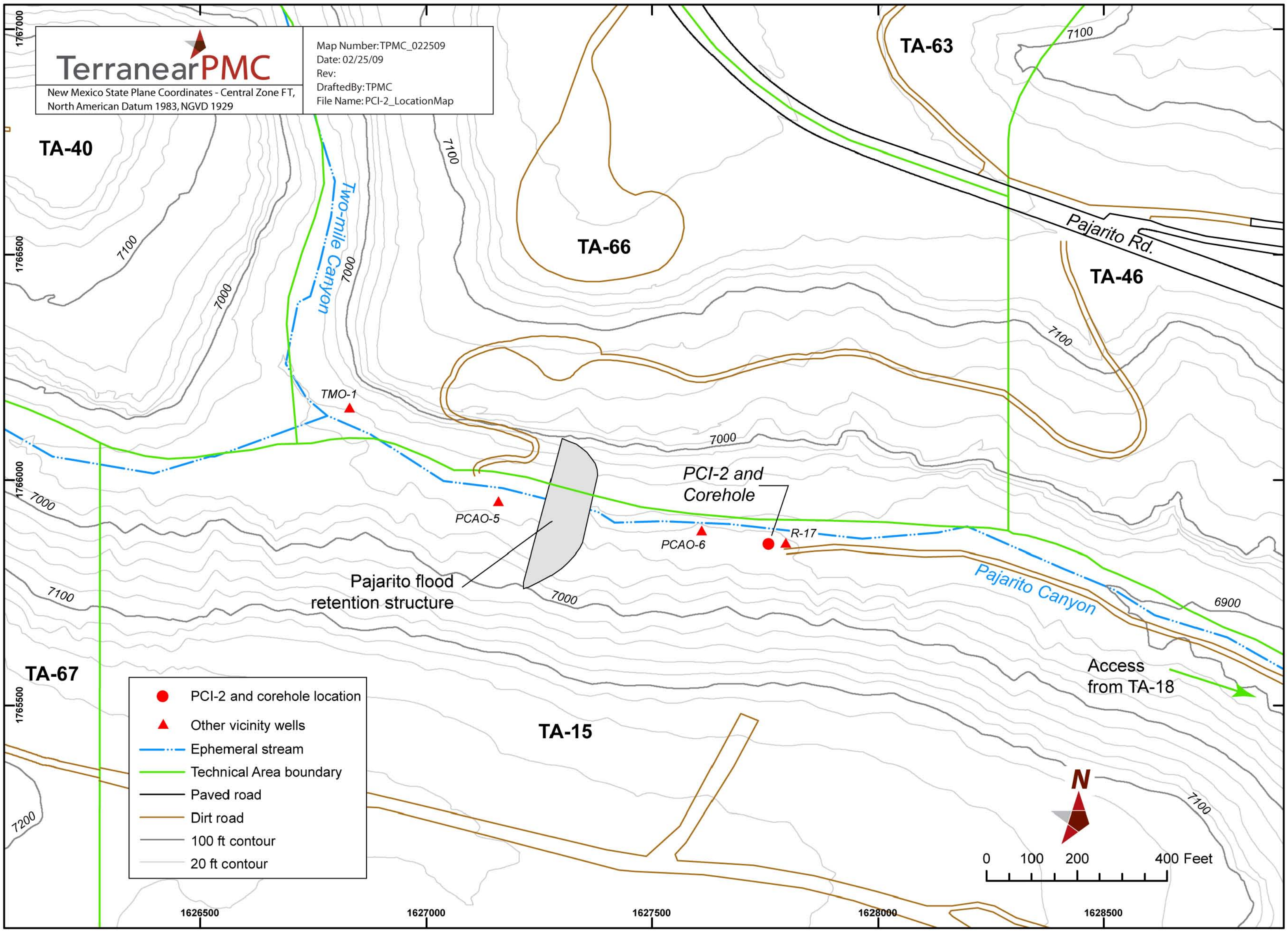

Figure 1.0-1 Location of monitoring well and core hole PCI-2 with respect to surrounding alluvial and regional well R-17

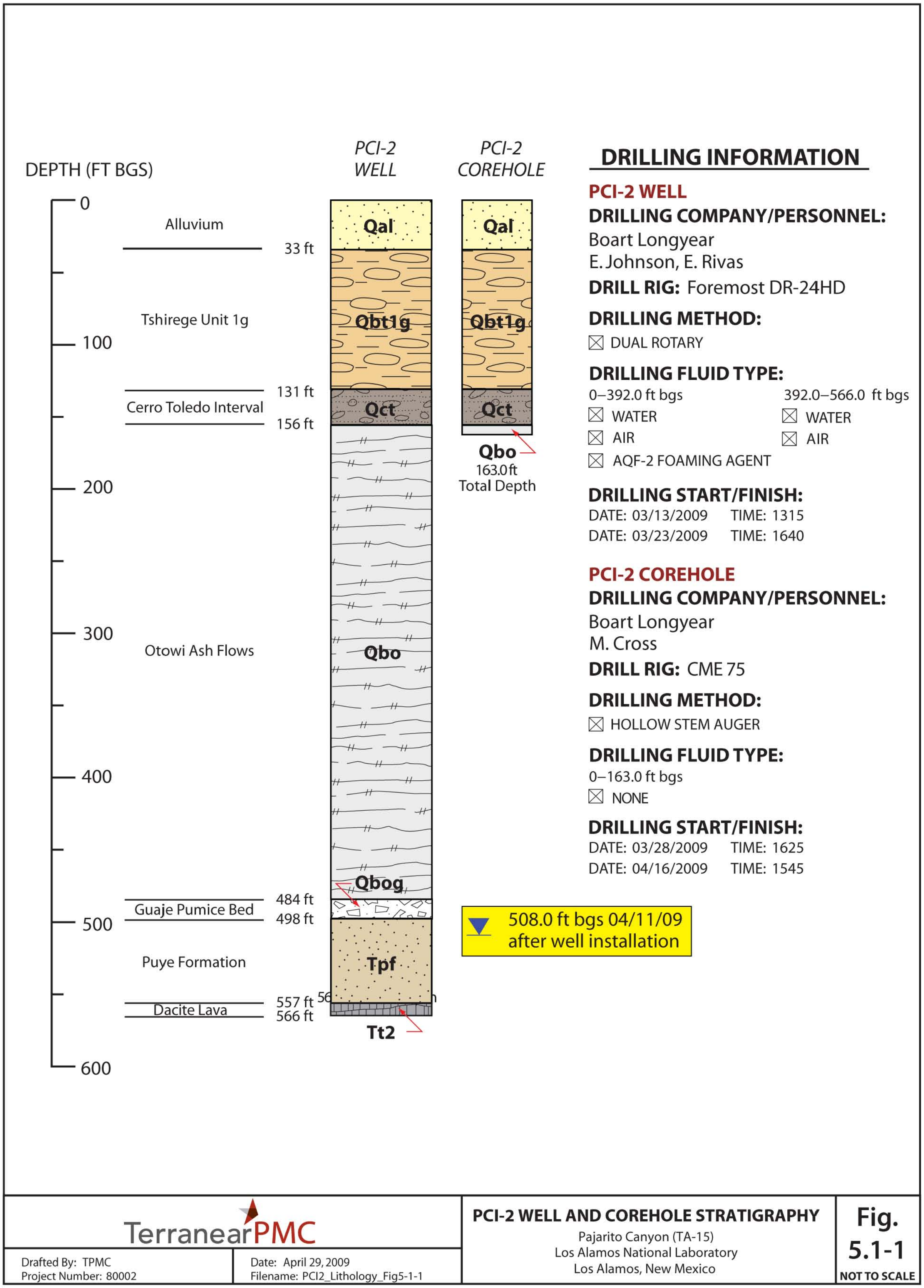

Figure 5.1-1 Monitoring well and core hole PCI-2 borehole stratigraphy

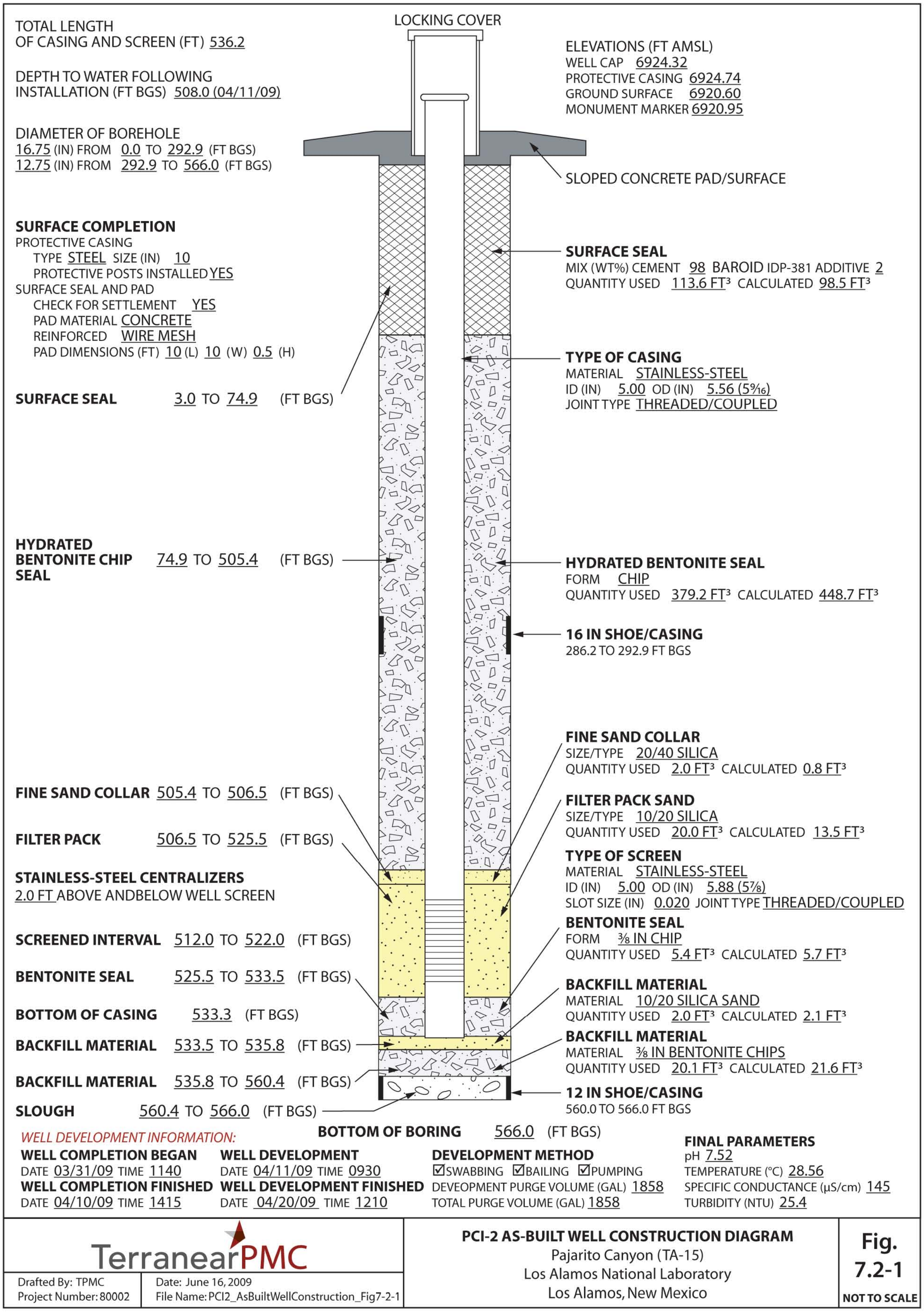

Figure 7.2-1 Monitoring well PCI-2 as-built well construction diagram

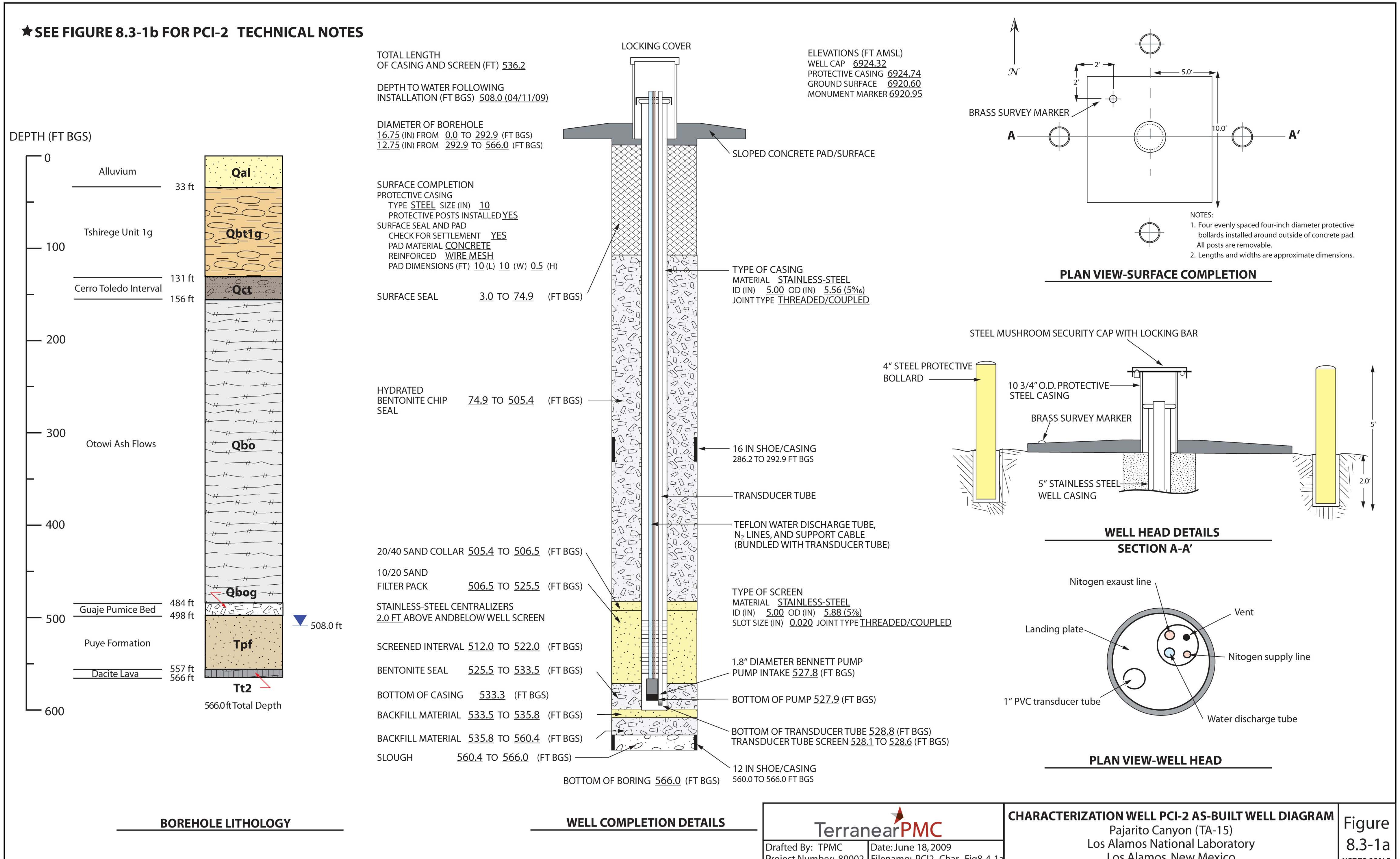

Figure 8.3-1a As-built schematic for intermediate perched water monitoring well PCI-2

PCI-2 TECHNICAL NOTES:

SURVEY INFORMATION*

Brass Marker
Northing: 1765872.63 ft
Easting: 1627648.27 ft
Elevation: 6920.95 ft AMSL

Well Casing (top of stainless steel)
Northing: 1765867.97 ft
Easting: 1627651.86 ft
Elevation: 6924.32 ft AMSL

BOREHOLE GEOPHYSICAL LOGS

LANL: Video, natural gamma ray, and induction

DRILLING INFORMATION

Drilling Company
Boart Longyear

Drill Rig
Foremost DR-24HD

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

Drilling Fluids
Air, potable water, AQF-2 Foam

MILESTONE DATES

Drilling
Start: 03/13/2009
Finished: 03/23/2009

Well Completion
Start: 03/31/2009
Finished: 04/10/2009

Well Development
Start: 04/11/2009
Finished: 04/20/2009

WELL DEVELOPMENT

Development Methods
Performed swabbing, bailing, and pumping
Total Volume Purged: 1858 gallons

Parameter Measurments (Final)
pH: 7.52
Temperature: 28.56°C
Specific Conductance: 145 µS/cm
Turbidity: 25.4 NTU

AQUIFER TESTING

Not tested

DEDICATED SAMPLING SYSTEM

Pump
Make: Bennett Sample Pumps, Inc.
Model: 180-6 submersible piston pump
S/N: 186-461
Intake: 527.8 ft bgs (mid-point)

Motor
None, nitogen activated

Pump Column
Teflon water discharge tubing with polyproplene gas lines (DPT1 tube bundle)

Transducer Tube
1-in. flush threaded schd. 80 PVC tubing
0.01-in. slot screen at 528.1–528.6 ft bgs

Transducer
Make: In-Situ Inc.
Model: Level Troll 500
30 psi (vented)
S/N: 146-149

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

TerranearPMC
Drafted By: TPMC
Project Number: 80002
Date: June 18, 2009
Filename: PCI2_TechnicalNotes_Fig8-3-1b_r2

PCI-2 TECHNICAL NOTES
Pajarito Canyon (TA-15)
Los Alamos National Laboratory
Los Alamos, New Mexico

Figure 8.3-1b
NOT TO SCALE

Figure 8.3-1b As-built technical notes for monitoring well PCI-2

Table 3.1-1
Fluid Quantities Used during Drilling and Well Construction PCI-2 Monitoring Well

Date	Water (gal.)	Cumulative Water (gal.)	AQF-2 Foam (gal.)	Cumulative AQF-2 Foam (gal.)
Drilling				
03/13/09	400	400	1	1
03/14/09	800	1200	5	6
03/15/09	800	2000	7	13
03/16/09	100	2100	1	14
03/19/09	1300	3400	10	24
03/20/09	1700	5100	0	24
03/22/09	1000	6100	0	24
03/23/09	1000	7100	0	24
Well Construction				
03/24/09	200	7300	n/a*	24
03/25/09	2000	9300	n/a	24
04/02/09	200	9500	n/a	24
04/03/09	1300	10800	n/a	24
04/05/09	2500	13300	n/a	24
04/07/09	3000	16300	n/a	24
04/08/09	1600	17900	n/a	24
04/09/09	560	18460	n/a	24
04/10/09	35	18495	n/a	24
Total Volume (gal.)				
PCI-2	18495			

* n/a = Not applicable. Foam use and pit use discontinued after drilling activities; therefore, no additional fluids were produced.

Table 4.2-1
Summary of Groundwater-Screening Samples Collected during Drilling, Well Development, and Aquifer Testing of Monitoring Well PCI-2

Location ID	Sample ID	Date Collected	Collection Depth (ft bgs)	Sample Type	Analysis
Drilling					
PCI-2	CAPA-09-5802	03/14/09	139.5	Groundwater	Tritium
PCI-2	CAPA-09-5803	03/14/09	139.5	Groundwater	Tritium
PCI-2	CAPA-09-5804	03/15/09	141.5	Groundwater	Tritium
PCI-2	CAPA-09-5805	03/15/09	233.0	Groundwater	Tritium
PCI-2	CAPA-09-5806	03/15/09	233.0	Groundwater	Tritium
PCI-2	CAPA-09-5807	03/16/09	253.0	Groundwater	Tritium
PCI-2	CAPA-09-5808	03/16/09	253.0	Groundwater	Tritium
PCI-2	CAPA-09-5762	03/22/09	510.0	Groundwater	Anions, metals
PCI-2	CAPA-09-5809	03/22/09	510.0	Groundwater	Tritium
Well Development					
PCI-2	CAPA-09-5782	04/17/09	512.0–525.0	Groundwater	Anions, metals, TOC
PCI-2	CAPA-09-5783	04/19/09	512.0–525.0	Groundwater	Anions, metals, TOC
PCI-2	CAPA-09-5784	04/20/09	512.0–525.0	Groundwater	Anions, metals, TOC

Note: Tritium was submitted for off-site analysis.

Table 4.3-1
Summary of Core Samples Collected for Analysis during Drilling of PCI-2 Core Hole

Sample ID	Date Collected	Collection Depth (ft bgs)	Geologic Zone	Analyses
CAPA-09-7486	04/14/09	23.0–23.5	Qal	Anions, perchlorate
CAPA-09-7486	04/14/09	23.5–24.0	Qal	VOCs
CAPA-09-7486	04/14/09	24.0–24.5	Qal	Tritium
CAPA-09-7487	04/14/09	30.5–31.0	Qal	VOCs
CAPA-09-7487	04/14/09	31.0–31.5	Qal	Tritium
CAPA-09-7487	04/14/09	31.5–32.5	Qal	Anions, perchlorate
CAPA-09-7488	04/15/09	37.5–38.3	Qbt 1g	Anions, perchlorate
CAPA-09-7488	04/15/09	38.3–39.1	Qbt 1g	VOCs
CAPA-09-7488	04/15/09	39.1–40.0	Qbt 1g	Tritium
CAPA-09-7489	04/15/09	52.5–53.0	Qbt 1g	Anions, perchlorate
CAPA-09-7489	04/15/09	53.0–53.5	Qbt 1g	VOCs
CAPA-09-7489	04/15/09	53.5–54.0	Qbt 1g	Tritium
CAPA-09-7490	04/15/09	62.5–63.0	Qbt 1g	Anions, perchlorate
CAPA-09-7490	04/15/09	63.0–63.5	Qbt 1g	VOCs
CAPA-09-7490	04/15/09	63.5–64.0	Qbt 1g	Tritium
CAPA-09-7491	04/15/09	82.5–83.0	Qbt 1g	Anions, perchlorate
CAPA-09-7491	04/15/09	83.0–83.5	Qbt 1g	VOCs
CAPA-09-7491	04/15/09	83.5–84.0	Qbt 1g	Tritium
CAPA-09-7492	04/15/09	92.5–93.0	Qbt 1g	Anions, perchlorate
CAPA-09-7492	04/15/09	93.0–93.5	Qbt 1g	VOCs
CAPA-09-7492	04/15/09	93.5–94.0	Qbt 1g	Tritium
CAPA-09-7493	04/15/09	100.0–100.4	Qbt 1g	Anions, perchlorate
CAPA-09-7493	04/15/09	100.4–100.8	Qbt 1g	VOCs
CAPA-09-7493	04/15/09	100.8–101.3	Qbt 1g	Tritium
CAPA-09-7494	04/16/09	120.0–120.6	Qbt 1g	Anions, perchlorate
CAPA-09-7494	04/16/09	120.6–121.3	Qbt 1g	VOCs
CAPA-09-7494	04/16/09	121.3–121.8	Qbt 1g	Tritium
CAPA-09-7495	04/16/09	139.5–140.0	Qct	Anions, perchlorate
CAPA-09-7495	04/16/09	140.0–140.5	Qct	VOCs
CAPA-09-7495	04/16/09	140.5–141.0	Qct	Tritium
CAPA-09-7496	04/16/09	161.5–162.0	Qbo	Anions, perchlorate
CAPA-09-7496	04/16/09	162.0–162.5	Qbo	VOCs
CAPA-09-7496	04/16/09	162.5–163.0	Qbo	Tritium

Table 6.0-1
PCI-2 Monitoring Well and Core Hole Video and Geophysical Logging Runs

Date	Depth (ft bgs)	Description
03/16/09	0.0–292.9	LANL personnel ran a natural gamma-ray log inside the 16-in. casing before landing casing.
03/21/09	535.0	LANL personnel ran a video log inside the 12-in, casing with the bottom of the casing lifted 20.4 ft to 496.5 ft bgs. The camera revealed a water level at 504.8 ft bgs.
03/24/09	566.0	Ran LANL video camera to verify successful cut of 12-in. casing at 560.0 ft bgs
03/25/09	566.0	Final logging of borehole with LANL video, natural gamma ray, and induction tools. Twelve-inch casing above cut retracted to 484.6 ft bgs before logging. Video showed water entering the borehole at approximately 510 ft bgs and increasing with depth to a static water level measured at 536.5 ft bgs beforehand.
04/17/09	163.0	Core hole - LANL personnel ran a video survey with the augers retracted to 137.5 ft bgs; no water was observed in the borehole.

Table 7.2-1
PCI-2 Monitoring Well Annular Fill Materials

Material	Volume (ft^3)
Surface seal: cement slurry	113.6
Upper seal: bentonite chips	379.2
Fine sand collar: 20/40 silica sand	2.0
Filter pack: 10/20 silica sand	20.0
Lower seal: bentonite chips	5.4
Backfill: 10/20 silica sand	2.0
Backfill: bentonite chips	20.1

Table 8.5-1
PCI-2 Monitoring Well Survey Coordinates

Identification	North	East	Elevation
PCI-2 brass pin embedded in pad	1765872.63	1627648.27	6920.95
PCI-2 ground surface near pad	1765872.56	1627646.18	6920.60
PCI-2 top of 10-in. protective casing	1765867.91	1627651.63	6924.74
PCI-2 top of stainless-steel well casing	1765867.97	1627651.86	6924.32

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

Table 8.5-2
PCI-2 Core Hole Survey Coordinates

Identification	North	East	Elevation
PCI-2 (abandoned) core hole location	1765872.45	1627735.46	6921.5

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

Table 8.6-1
Summary of Waste Samples Collected during
Drilling and Development of PCI-2 Monitoring Well and Core Hole

Location ID	Sample ID	Date Collected	Description	Sample Type
PCI-2	n/a*	n/a	Contact waste, use AK from drill cuttings	Solid
PCI-2	RC18-09-5711	04/13/09	Decon water	Liquid
PCI-2	RC18-09-5712	04/13/09	Decon water	Liquid
PCI-2	RC18-09-5713	04/13/09	Decon water	Liquid
PCI-2	RC18-09-5713	04/13/09	Decon water	Liquid
PCI-2	RC18-09-5723	04/13/09	Drilling fluid	Liquid
PCI-2	RC18-09-5724	04/13/09	Drilling fluid	Liquid
PCI-2	RC18-09-5725	04/13/09	Drilling fluid	Liquid
PCI-2	RC18-09-5726	04/13/09	Drilling fluid	Liquid
PCI-2	RC18-09-5743	05/13/09	Drill cuttings	Solid
PCI-2	RC18-09-5744	05/13/09	Drill cuttings	Solid
PCI-2	RC18-09-5735	04/21/09	Development water	Liquid
PCI-2	RC18-09-5736	04/21/09	Development water	Liquid
PCI-2	RC18-09-5737	04/21/09	Development water	Liquid
PCI-2	RC18-09-5738	04/21/09	Development water	Liquid
PCI-2	CAPA-09-8105	05/13/09	Petroleum contaminated soil	Solid
PCI-2	CAPA-09-8106	05/13/09	Petroleum contaminated soil	Solid
PCI-2	CAPA-09-8107	05/13/09	Petroleum contaminated soil	Solid
PCI-2 CH	CAPA-09-8108	04/17/09	Decon water, augers	Liquid
PCI-2 CH	CAPA-09-8109	04/17/09	Decon water, augers	Liquid
PCI-2 CH	CAPA-09-8110	04/17/09	Decon water, augers	Liquid
PCI-2 CH	CAPA-09-8111	04/17/09	Decon water, augers	Liquid

*n/a = Not applicable.

Appendix A

Borehole PCI-2 Lithologic Log

Los Alamos National Laboratory
Regional Hydrogeologic Characterization Project
Borehole Lithologic Log

BOREHOLE IDENTIFICATION (ID): PCI-2	**TECHNICAL AREA (TA):** 15	**PAGE:** 1 of 12
DRILLING COMPANY: Boart Longyear Company	**START DATE/TIME:** 03/13/2009: 1315	**END DATE/TIME:** 03/23/2009: 1640
DRILLING METHOD: Dual Rotary	**MACHINE**: Foremost DR24 HD	**SAMPLING METHOD:** Grab
GROUND ELEVATION: 6920.60 amsl	**TOTAL DEPTH:** 566 ft bgs	
DRILLERS: C. Johnson, E. Rivas	**SITE GEOLOGISTS:** C. Pigman, J. R. Lawrence	

DEPTH (ft bgs)	LITHOLOGY	LITHOLOGIC SYMBOL	NOTES
0–10	**ALLUVIUM:** Tuffaceous sediments—pale brown (5YR 5/2), unconsolidated silty fine to coarse sand with granules, detritus of tuffaceous and volcanic-derived materials. 0–10 ft WR: organic-rich silty sand. +10F: subangular granules composed of quartz and sanidine crystals, fragments of indurated tuff and predominantly dacitic lithics; abundant organic matter (root segments, wood fragments, bark).	Qal	Note: Drill cuttings for microscopic and descriptive analysis were collected at 5-ft intervals from 0 ft to borehole TD at 566 ft bgs. Alluvial sediments, encountered from 0 ft to 33 ft, are approximately 33 ft thick.
10–33	Tuffaceous sediments—grayish orange pink (5YR 7/2), unconsolidated, tuffaceous, silty fine to medium sand with pebble gravel. 10–33 ft +10F: angular silt-coated detrital fragments of porphyritic dacite, welded crystal-tuff and quartz and sanidine crystals.		The Qal–Qbt 1g contact is estimated to be at 33 ft bgs based on drill cuttings and natural gamma ray log data.
33–40	**UNIT 1g OF THE TSHIREGE MEMBER OF THE BANDELIER TUFF:** Tuff—grayish orange pink (5YR 7/2), poorly welded, pumiceous, lithic- and crystal-bearing, pumices characteristically glassy. 33–40 ft+10F: 75%–85% white glassy, fibrous-textured pumices that are quartz- and sanidine-phyric and commonly display streaks and blebs of black obsidian indicating local remelting of pumiceous glass; 15%–25% angular to subangular dacitic lithics (up to 7 mm in diameter). +35F: 50%–60% quartz and sanidine crystals locally with remelted rinds; 40%–50% glassy pumices with streaks of black obsidian; 3%–5% dacite and minor obsidian grains.	Qbt 1g	Unit 1g of the Tshirege Member of the Bandelier Tuff (Qbt 1g), encountered from 33 to 131 ft bgs, is estimated to be 98 ft thick.

Borehole Lithologic Log (continued)

Borehole ID: PCI-2	**TA:** 15		**Page:** 2 of 12
DEPTH (ft bgs)	**LITHOLOGY**	**LITHOLOGIC SYMBOL**	**NOTES**
40–55	Tuff—very pale orange (10YR 8/2), poorly welded, strongly pumiceous, crystal- and lithic-bearing. 40–55 ft WR: abundant volcanic ash. +10F: 85%–95% rounded pumice lapilli and fragments that are white, glassy, fibrous-textured and quartz-and sanidine-phyric; 5%–15% subangular dacitic lithics (up to 7 mm in diameter). +35F: 50%–70% fragments of glassy pumice; 30–50% quartz and sanidine crystals; 3%–5 % grains of dacite and minor obsidian.	Qbt 1g	
55–75	Tuff— very pale orange (10YR 8/2), poorly welded, strongly pumiceous, crystal-bearing lithic-poor. 55–75 ft WR: ash-rich samples with abundant pumice lapilli. +10F: 99%–100% subrounded pumice lapilli (up to 12 mm in diameter), glassy, quartz- and sanidine-phyric exhibiting small clots of secondary iron oxides; up to 1% subrounded dacite lithics (up to 7 mm in diameter). +35F: 50%–60% quartz and sanidine crystals; 40%–50% glassy pumice fragments; 1%–3% dacite and minor obsidian lithic grains.	Qbt 1g	
75–95	Tuff— very pale orange (10YR 8/2), poorly welded, strongly pumiceous, crystal-bearing lithic-poor. 75–95 ft WR: ash-rich samples with abundant pumice lapilli. +10F: 98%–99% white glassy pumice lapilli (up to 18 mm in diameter), locally rounded, quartz- and sanidine-phyric; up to 1% dacitic lithic fragments. +35F: 40%–50% quartz and sanidine crystals; 40%–50% fragments of glassy pumice fragments; 1%–3% dacitic lithic grains.	Qbt 1g	
95–115	Tuff— very pale orange (10YR 8/2), poorly welded, strongly pumiceous, crystal-bearing lithic-poor. 95–115 ft WR: ash-rich samples with abundant pumice lapilli. +10F: 99%–100% white to very pale orange glassy pumice lapilli (up to 16 mm in diameter), partly rounded, quartz- and sanidine-phyric; up to 1% small (up to 5 mm in diameter) dacite lithic fragments. +35F: quartz and sanidine crystals, fragments of glassy pumice fragments in varying proportions throughout the interval; 1%–2% dacitic lithic grains.	Qbt 1g	

Borehole Lithologic Log (continued)

Borehole ID: PCI-2	**TA:** 15		**Page:** 3 of 12
DEPTH (ft bgs)	**LITHOLOGY**	**LITHOLOGIC SYMBOL**	**NOTES**
115–131	Tuff— very pale orange (10YR 8/2), poorly welded, strongly pumiceous, crystal- and lithic-bearing. 115–131 ft WR: ash-rich samples with abundant pumice lapilli. +10F: 85%–95% very pale orange glassy pumice lapilli (up to 11 mm in diameter), partly rounded, quartz- and sanidine-phyric, small clots of secondary black iron and/or manganese oxides; up to 5%–10% small (up to 8 mm in diameter) subangular to subrounded dacitic lithic fragments. +35F: quartz and sanidine crystals, fragments of glassy pumice fragments in varying proportions throughout the interval; 1%–3% dacitic lithic grains.	Qbt 1g	The estimated Qbt 1g–Qct contact at 131 ft bgs is based on drill cuttings and natural gamma-ray log interpretation.
131–135	**CERRO TOLEDO INTERVAL:** Tuffaceous sediments—very pale orange (10YR 8/2) silty fine to coarse sand with granules, detritus primarily of subrounded pumice, lesser dacitic clasts. 131–135 ft WR: abundant pale orange silt matrix. +10F: 90%–95% very pale orange sunrounded glassy pumice clasts; 5%–10% angular to subangular dacitic lithic fragments.	Qct	The Cerro Toledo Interval (Qct), encountered from 131 to 156 ft bgs, is estimated to be 25 ft thick.
135–156	Tuffaceous sediments—light brownish gray (5YR 6/1) fine to coarse sand with silt and pebble gravel, frequently rounded detritus of dacite and lesser pumice. 135–150 ft +10F: 20%–25% very pale orange rounded vitric pumices (up to 10 mm in diameter); 75%–80% broken and subrounded to well rounded volcanic clasts (up to 17 mm in diameter) composed predominantly of hornblende- and biotite-phyric dacites. Note: the proportion of dacitic to pumiceous detritus increases downward in the interval. +35F: varying proportions of vitric pumices, quartz and sanidine crystals, and subangular to subrounded dacitic grains; becoming dacite-rich downward in the interval. 150–156 ft +10F: 15%–20% rounded very pale orange rounded vitric; 80%–85% broken and subrounded clasts (up to 11 mm in diameter) composed of varieties of gray dacite.	Qct	The estimated Qct–Qbo contact, at 156 ft bgs, is interpreted from drill cuttings and natural gamma ray log data.

Borehole Lithologic Log (continued)

Borehole ID: PCI-2	**TA:** 15		**Page:** 4 of 12
DEPTH (ft bgs)	**LITHOLOGY**	**LITHOLOGIC SYMBOL**	**NOTES**
156–165	**OTOWI MEMBER OF THE BANDELIER TUFF:** Tuff—varicolored, pale yellowish orange (10YR 8/6) to light medium gray (N6), poorly welded, lithic-rich, crystal-poor, pumiceous. No indurated tuff fragments present. 156–165 ft WR/+10F: 30%–35% orange-tan vitric pumice fragments; 65%–70% subangular to subrounded volcanic lithics (typically up to 3 mm in diameter), predominantly dacite, trace andesite. +35F: 15%–20% vitric pumice fragments; 10%–15% quartz and sanidine crystals; 60%–70% volcanic lithics.	Qbo	The Otowi Member of the Bandelier Tuff (Qbo), intersected from 156 ft to 484 ft bgs, is estimated to be 328 ft thick.
165–180	Tuff—grayish orange (10YR 7/4) to very light gray (N8), poorly welded, lithic-rich, pumiceous, crystal-bearing. No indurated tuff fragments present. 165–180 ft WR: small percentage of volcanic ash preserved. +10F: 20%–50% pale orange vitric pumice fragments, quartz- and sanidine-phyric; 50%–80% broken and subangular volcanic lithics (predominantly dacite, trace andesite).	Qbo	
180–200	Tuff—very pale orange (10YR 8/2) to very light gray (N8), poorly welded, lithic-rich, pumice- and crystal-bearing. No indurated tuff fragments present. 180–200 ft +10F: 10%–20% orange-tan vitric pumice fragments that are quartz- and sanidine-bearing; 80%–90% volcanic lithics (up to 10 mm in diameter) composed of various dacite, dacite vitrophyre, dark gray andesite, fine-grained rhyolite. +35F: 5%–15% vitric pumice fragments; 40%–50% quartz and sanidine crystals; 30%–40% volcanic lithic grains, predominantly dacitic.	Qbo	
200–220	Tuff—varicolored, very pale orange (10YR 8/2) to very light gray (N8), poorly welded, lithic-rich, pumiceous, crystal-bearing. No indurated tuff fragments present. 220–205 ft +10F: 60$–70% pale orange to white vitric pumice fragments that are quartz- and sanidine-bearing; 30$–40% broken and subangular volcanic lithics composed predominantly of hornblende- and biotite-phyric dacites. 205–220 ft +10F: 20%–40% vitric pumice fragments; 60%–80% subangular to subrounded dacitic lithic fragments. +35F: variable percentages of vitric pumice fragments, quartz and sanidine crystals, and volcanic lithic grains throughout the interval.	Qbo	

Borehole Lithologic Log (continued)

Borehole ID: PCI-2	**TA:** 15		**Page:** 5 of 12
DEPTH (ft bgs)	**LITHOLOGY**	**LITHOLOGIC SYMBOL**	**NOTES**
220–235	Tuff—varicolored, very pale orange (10YR 8/2) to very light gray (N8), poorly welded, lithic-rich, pumiceous, crystal-bearing. No indurated tuff fragments present. 220–205 ft +10F: 30%–40% orange-tan to white vitric quartz- and sanidine-phyric pumice fragments; 60%–70% volcanic lithics (up to 7 mm in diameter) composed predominantly of hornblende- and biotite-phyric dacites, minor andesite. +35F: variable percentages of vitric pumice fragments, quartz and sanidine crystals, and volcanic lithic grains throughout the interval.	Qbo	
235–255	Tuff—varicolored, very pale orange (10YR 8/2) to very light gray (N8), poorly welded, lithic-rich, pumiceous, crystal-bearing. Sample constituents uniformly small (up to 3 mm in diameter) throughout the interval. No indurated tuff fragments present. 220–205 ft +10F: 40%–50% well-rounded pale orange vitric pumices that are quartz- and sanidine-bearing; 40%–50% subrounded to rounded volcanic lithics composed predominantly of hornblende- and biotite-phyric dacites. +35F: variable percentages of vitric pumice fragments, quartz and sanidine crystals, and volcanic lithic grains throughout the interval.	Qbo	
255–265	Tuff—varicolored, very pale orange (10YR 8/2) to very light gray (N8), poorly welded, lithic-rich, pumiceous, crystal-bearing. No indurated tuff fragments present. 255–265 ft WR: abundant pale orange volcanic ash. +10F: very small volume of this sample fraction produced; predominantly glassy pumice fragments, lesser dacitic lithics. +35F: 20%–30% vitric pumice fragments, 20%–30% quartz and sanidine crystals; 50%–60% volcanic lithic grains.	Qbo	

Borehole Lithologic Log (continued)

Borehole ID: PCI-2	**TA:** 15		**Page:** 6 of 12
DEPTH (ft bgs)	**LITHOLOGY**	**LITHOLOGIC SYMBOL**	**NOTES**
265–290	Tuff—medium gray (N8) to very light gray (N8), poorly welded, lithic-rich, pumiceous, crystal-bearing. No indurated tuff fragments present. 265–285 ft WR: moderate abundance of volcanic ash preserved. +10F: 20%–40% pale orange-tan to white vitric pumice fragments (up to 15 mm) that are quartz- and sanidine-phyric; 60%–80% broken and subangular volcanic lithics (up to 17 mm in diameter) composed predominantly of hornblende- and biotite-phyric dacites, brown andesite, rounded black obsidian. 265–275 ft +35F: 30%–40% quartz and sanidine crystals that commonly exhibit remelted crystal surfaces; 25%–35% pumice fragments; 30%–40% volcanic lithic grains. 275–285 ft +35F: 20%–30% vitric pumice fragments; 50%–60% quartz and sanidine crystals; 10%–20% volcanic lithic grains. 285–290 ft cuttings sample missing.	Qbo	265–285 ft pumice lapilli are locally dark gray with distinctive streaks of obsidian.
290–320	Tuff—medium gray (N8) to very light gray (N8), poorly welded, lithic-rich, pumiceous, crystal-bearing. No indurated tuff fragments present. 290–295 ft WR: moderate abundance of volcanic ash preserved. +10F: 90% broken (up to 7 mm in diameter) and subangular volcanic lithic fragments composed predominantly of hornblende- and biotite-phyric dacites, brown andesite, minor black obsidian; 10% vitric pumice fragments. 295–305 ft +10F: 70%–80% subrounded vitric, quartz- and sanidine-phyric pumice lapilli (up to 10 m in diameter) with clots of black secondary iron and/or manganese oxides; 20%–30% broken and subangular volcanic lithic fragments (up to 20 mm in diameter) composed of coarsely porphyritic gray dacites and minor brown fine-grained andesite(?). 305–320 +10F: 40%–50% vitric, quartz- and sanidine-phyric pumice lapilli, white, vitreous luster; 50%–60% volcanic lithic fragments composed of gray porphyritic and flow-banded dacites, minor brown fine-grained andesite(?), trace black vitrophyre.	Qbo	

Borehole Lithologic Log (continued)

Borehole ID: PCI-2	**TA:** 15		**Page:** 7 of 12
DEPTH (ft bgs)	**LITHOLOGY**	**LITHOLOGIC SYMBOL**	**NOTES**
320–335	Tuff—grayish orange pink (10YR 7/4), poorly welded, lithic-rich, pumiceous, crystal-bearing. No indurated tuff fragments present. 320–330 ft WR: moderate to abundant pale orange tan vitric ash preserved. +10F: 10%–20% white vitric pumice fragments that are quartz- and sanidine-phyric; 80%–90% broken and subangular volcanic lithics composed predominantly of gray dacites. +35F: 10%–20% quartz and sanidine crystals; 50%–70% vitric pumice fragments; 50%–70% volcanic lithic grains. 330–335 +10F: 99%–100% rounded to well rounded white vitric pumices; up to 1% dacite lithics.	Qbo	
335–355	Tuff—pale yellowish gray (5YR 8/1) to medium light gray (N6), poorly welded, lithic-rich, pumiceous, crystal-bearing. Little matrix ash and no indurated tuff fragments present. 335–355 ft +10F: 20%–30% white vitric pumice fragments that are quartz- and sanidine-phyric; 70%–80% broken (up to 20 mm in diameter) and subangular volcanic lithics composed of gray hornblende- and biotite-phyric dacites, brown fine-grained andesite(?), dark gray dacitic vitrophyre. +35F: variable proportions of quartz and sanidine crystals, vitric pumice fragments and volcanic lithic grains throughout the interval.	Qbo	
355–375	Tuff—pale yellowish gray (5YR 8/1) to medium light gray (N6), poorly welded, lithic-rich, pumiceous, crystal-bearing. Little matrix ash and no indurated tuff fragments present. 355–355 ft +10F: 30%–50% subrounded white vitric pumice fragments that are quartz- and sanidine-phyric and have distinctive streaks of dark gray obsidian; 50%–70% broken and subangular to subrounded volcanic lithics (up to 12 mm in diameter) composed of gray hornblende- and biotite-phyric dacites and dark gray dacite vitrophyre. +35F: variable proportions of quartz and sanidine crystals, vitric pumice fragments and volcanic lithic grains throughout the interval.	Qbo	

Borehole Lithologic Log (continued)

Borehole ID: PCI-2	**TA:** 15		**Page:** 8 of 12
DEPTH (ft bgs)	**LITHOLOGY**	**LITHOLOGIC SYMBOL**	**NOTES**
375–395	Tuff—pale yellowish gray (5YR 8/1) to medium light gray (N6), poorly welded, lithic-rich, pumiceous, crystal-bearing. Little matrix ash and no indurated tuff fragments present. 375–395 ft WR: abundant orange-tan to light tan silty volcanic ash matrix. 375–380 ft +10F: 65%–70% commonly rounded white to very pale orange vitric pumice fragments that are quartz- and sanidine-phyric; 25%–35% angular to subangular (up to 13 mm in diameter) volcanic lithics composed of gray dacites. +35F: 15%–20% quartz and sanidine crystals, 70%–80% vitric pumice fragments; 5%–10% volcanic lithic grains. 380–395 ft +10F: 80%–90% pale orange vitric pumice; 1%–20% volcanic lithics.	Qbo	
395–415	Tuff—yellowish brown (10YR 6/6) to very pale orange (10YR 8/2), poorly welded, pumiceous lithic-rich, crystal-bearing. No indurated tuff fragments present. 395–415 ft +10F: 50%–60% commonly rounded pale orange vitric pumice lapilli; 40%–50% commonly rounded dacitic lithics. +35F: 10%–15% quartz and sanidine crystals; 30%–40% vitric pumice fragments; 40%–50% dacitic lithic grains.	Qbo	
415–430	Tuff—light reddish brown (5YR 5/6) to very pale orange (10YR 8/2), poorly welded, pumiceous lithic-rich, crystal-poor. No indurated tuff fragments present. 415–420 ft WR: abundant pale orange silty ash matrix. +10F: 90%–95% very pale orange vitric pumice lapilli; 5%–10% dacitic lithics. +35F: 7–10% quartz and sanidine crystals; 85%–90% vitric pumice fragments; 3%–5% dacitic lithic grains. 420–430 ft WR: abundant pale orange silty ash matrix. +10F: 20%–40% rounded pale orange vitric, quartz- and sanidine-phyric pumice lapilli; 60%–80% subangular to subrounded volcanic lithic fragments (up to 8 mm in diameter) composed of gray hornblende-dacite, biotite-dacite, brown andesite.	Qbo	

Borehole Lithologic Log (continued)

Borehole ID: PCI-2	**TA:** 15		**Page:** 9 of 12
DEPTH (ft bgs)	**LITHOLOGY**	**LITHOLOGIC SYMBOL**	**NOTES**
430–450	Tuff—light reddish brown (5YR 5/6) to very pale pinkish gray (5YR 8/1), poorly welded, pumiceous lithic-rich, crystal-poor. No indurated tuff fragments present. 430–450 ft WR: abundant pale pinkish gray silty ash matrix. 430–435 ft +10F: 70%–75% very pale orange vitric pumice fragments; 25%–30% volcanic lithics (typically up to 10 mm) composed of gray hornblende-and/or biotite-phyric dacites. 435–440 ft +10F: 40%–50% pale orange vitric pumice lapilli; 50%–60% dacite lithics. 440–445 ft +10F: 95%–97% rounded very pale orange vitric pumices; 2%–5% dacitic. 445–450 ft +10F: 25%–30% rounded very pale orange vitric pumices; 70%–75% angular to subangular dacitic lithics (up to 3 mm in diameter).	Qbo	
450–470	Tuff—light reddish brown (5YR 5/6) to very pale orange (10YR 8/2), poorly welded, pumiceous lithic-rich, crystal-poor. No indurated tuff fragments present. 450–470 ft WR: abundant pale pinkish gray silty ash matrix. +10F: 50%–60% rounded pale orange vitric pumices, quartz- and sanidine-phyric; 40%–50% small (up to 5 mm in diameter) subangular to surrounded volcanic lithics predominantly of dacitic composition. +35F: highly variable proportions of quartz and sanidine crystals, vitric pumice fragments and dacitic lithic grains throughout the interval.	Qbo	
470–484	Tuff—light reddish brown (5YR 5/6) to very pale orange (10YR 8/2), poorly welded, pumiceous lithic-rich, crystal-poor. No indurated tuff fragments present. 470–484 ft WR: abundant pale pinkish gray silty ash matrix. +10F: 5%–15% rounded pale orange vitric pumices, quartz- and sanidine-phyric; 80%–85% small (up to 3 mm in diameter) subangular volcanic lithics predominantly of dacitic composition. +35F: highly variable proportions of quartz and sanidine crystals, vitric pumice fragments and dacitic lithic grains throughout the interval.	Qbo	The estimated Qbo–Qbog contact,at 484 ft bgs, is based on drill cuttings and natural gamma ray log interpretation.

Borehole Lithologic Log (continued)

Borehole ID: PCI-2	**TA:** 15		**Page:** 10 of 12
DEPTH (ft bgs)	**LITHOLOGY**	**LITHOLOGIC SYMBOL**	**NOTES**
484–498	**GUAJE PUMICE BED OF THE OTOWI MEMBER OF THE BANDELIER TUFF:** Tuff—pale pinkish gray (5YR 8/1) to moderate orange pink (5YR 8/4), unconsolidated, nonwelded, pumiceous, lithic-rich, crystal-bearing. 484–498 ft WR: abundant very pale pinkish gray volcanic ash. +10F 50%–60% white to very pale orange fresh-appearing to earthy textured vitric pumice (up to 7 mm in diameter); 40%–50% subangular to rounded dacitic lithics (up to 8 mm in diameter); +35F: variable proportions of quartz and sanidine crystals, vitric pumice fragments and dacitic lithic grains throughout the interval.	Qbog	The Guaje Pumice Bed (Qbog), intersected from 484 ft to 498 ft bgs, is estimated to be 15 ft thick.
498–510	**PUYE FORMATION:** Volcaniclastic sediments—light medium gray (N6) coarse gravel with fine to coarse sand, detrital clasts predominantly of light gray coarsely porphyritic dacites. 498–510 ft WR/+10F: 100% large broken chips (up to 30 mm in diameter) and subangular to subrounded pebble clasts composed almost entirely of hornblende- and/or biotite-phyric dacites. +35F: 99% subangular to subrounded dacite grains; 1% quartz and sanidine crystal grains.	Tpf	Puye volcaniclastic sediments (Tpf), intersected from 498 to 557 ft bgs, are estimated to be 59 ft thick.
510–530	Volcaniclastic sediments—light medium gray (N6) coarse gravel with fine to coarse sand, detrital clasts predominantly of light gray coarsely porphyritic dacites. 510–530 ft WR/+10F: 100% large broken chips (up to 25 mm in diameter) and subangular to subrounded pebble clasts composed of light gray porphyritic hornblende- and/or biotite-phyric dacites, minor black dacitic vitrophyre, white hornblende-dacite; local limonite staining of clasts. +35F: 100% angular to subangular dacitic grains.	Tpf	

Borehole Lithologic Log (continued)

Borehole ID: PCI-2	**TA:** 15		**Page:** 11 of 12
DEPTH (ft bgs)	**LITHOLOGY**	**LITHOLOGIC SYMBOL**	**NOTES**
530–545	Volcaniclastic sediments—light medium gray (N6) locally silty coarse gravel with fine to coarse sand, detrital clasts predominantly of light gray coarsely porphyritic dacites. 530–545 ft WR: locally silty matrix. +10F: 100% large broken chips and subangular to subrounded pebble clasts (up to 20 mm in diameter) composed predominantly of light gray porphyritic hornblende- and/or biotite-phyric dacites, minor black dacitic vitrophyre, white hornblende-dacite; local limonite staining of clasts. +35F: 100% angular chips/grains of light gray dacite and trace black dacitic vitrophyre.	Tpf	
545–557	Volcaniclastic sediments—light medium gray (N6) silty medium to fine gravels with fine to coarse sand, detrital clasts predominantly of light gray coarsely porphyritic dacites. 545–557 ft WR/+10F: 100% large broken chips and silt-coated subangular to subrounded pebble clasts (typically up to 12 mm in diameter) composed predominantly of light gray porphyritic hornblende- and/or biotite-phyric dacites, minor black dacitic vitrophyre, white hornblende-dacite; local limonite staining of clasts. +35F: nearly monolithologic angular chips/grains of light gray dacite.	Tpf	The estimated Tpf–Tt 2 contact at 557 ft bgs is based on analysis of drill cuttings and natural gamma-ray log data.
557–566	DACITIC LAVA: Dacitic lava–medium gray (N5) to medium dark gray (N4) and partly light red (5YR 6/2); broken chips composed of uniquely vesicular and massive pyroxene-phyric dacite. 557–566 ft +10F: 100% broken and subangular chips of mixed strongly vesicular to scoriaceous and massive phenocryst-poor dacitic lava, phenocrysts (1% by volume) of small (up to 1 mm in diameter) black opaque clinopyroxene in cumulophyric clusters with pale amber translucent orthopyroxene, aphanitic groundmass; local white calcium carbonate coating fractures.	Tt 2	A 9-ft interval of dacitic lava (Tt 2) was intersected from 557 ft to the bottom of the PCI-1 borehole at 566 ft bgs.

Borehole Lithologic Log (continued)

Borehole ID: PCI-2	**TA:** 15	**Page:** 12 of 12

ABBREVIATIONS

5YR 8/4 = Munsell rock color notation where hue (e.g., 5YR), value (e.g., 8), and chroma (e.g.,4) are expressed. Hue indicates soil color's relation to red, yellow, green, blue, and purple. Value indicates soil color's lightness. Chroma indicates soil color's strength

% = Estimated percent by volume of a given sample constituent.

amsl = Above mean sea level.

bgs = Below ground surface

GM = Groundmass.

Qal = Quaternary alluvium.

Qbo = Otowi Member of Bandelier Tuff.

Qbog = Guaje Pumice Bed.

Qbt = Tshirege Member of the BandelierTuff .

Qct = Cerro Toledo Interval.

Tb 4 = Cerros del Rio Basalt

Tpf = Puye Formation.

Tt 2 = Dacitic lava.

N/S = No assigned symbol for geologic unit

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

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

WR = Whole rock (unsieved sample).

1 mm = 0.039 in.

1 in. = 25.4 mm

Appendix B

Groundwater Analytical Results

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

A total of 12 groundwater samples were collected during drilling and well development at PCI-2. Nine groundwater-screening samples were collected at borehole PCI-2 during drilling within perched-intermediate saturated zones within the Puye Formation. Three groundwater-screening samples were collected from well PCI-2 during development. These groundwater samples were collected between the screened interval from 512.0 to 525.0 ft below ground surface (bgs). The filtered water samples collected from PCI-2 were analyzed for cations, anions, perchlorate, metals, and tritium. A total of 1858 gal. of groundwater was pumped from PCI-2 during development. An aquifer performance test was not conducted at PCI-2, based on the low hydraulic properties of this particular saturated zone within the Puye Formation.

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

Groundwater samples were analyzed using techniques specified by the U.S. Environmental Protection Agency (EPA) methods for water analyses. Ion chromatography (IC) (EPA Method 300, Rev. 2.1) was the analytical method for bromide, chloride, fluoride, nitrate, nitrite, oxalate, perchlorate, phosphate, and sulfate. The instrument detection limit for perchlorate was 0.005 ppm (EPA Method 314.0, Rev. 1). Inductively coupled (argon) plasma optical emission spectroscopy (ICPOES) (EPA Method 200.7, Rev. 4.4) was used for analyses of dissolved aluminum, barium, boron, calcium, total chromium, iron, lithium, magnesium, manganese, potassium, silica, sodium, strontium, titanium, and zinc. Dissolved aluminum, antimony, arsenic, barium, beryllium, boron, cadmium, cesium, chromium, cobalt, copper, iron, lead, lithium, manganese, mercury, molybdenum, nickel, rubidium, selenium, silver, thallium, thorium, tin, vanadium, uranium, and zinc were analyzed by inductively coupled (argon) plasma mass spectrometry (ICPMS) (EPA Method 200.8, Rev. 5.4). The precision limits (analytical error) for major ions and trace elements were generally less than ±7% using ICPOES and ICPMS. Total carbonate alkalinity (EPA Method 310.1) was measured using standard titration techniques. No groundwater samples were collected for total organic carbon (TOC) analyses at PCI-2 before well development. Analyses of TOC were performed on groundwater samples collected during well development and aquifer performance testing following EPA Method 415.1. Charge balance errors for total cations and anions were generally less than ±8% for complete analyses of the above inorganic chemicals. The negative cation-anion charge balance values indicate excess anions for the filtered samples.

Eight borehole water samples collected during drilling of PCI-2 were analyzed for tritium using the direct counting (seven samples) and electrolytic enrichment (one sample) methods performed by the University of Miami.

B-1.2 Field Parameters

B-1.2.1 Well Development

Water samples were drawn from the pump flow line into sealed containers, and field parameters were measured using a YSI multimeter. Results of field parameters, consisting of pH, temperature, dissolved oxygen (DO), oxidation-reduction potential (ORP), specific conductance, and turbidity measured during well development at PCI-2, are provided in Table B-1.2-1. Twenty-six measurements of pH and temperature varied from 7.18 to 8.46 and from 5.97°C to 28.56°C, respectively, in groundwater pumped from well PCI-2 during development. Reliable temperature measurements for perched intermediate groundwater ranged from 9°C to 20°C. Field temperature measurements provided for well PCI-2 that fall outside this range are not consistent with numerous temperature measurements made at other perched intermediate-depth wells drilled in Pueblo, Los Alamos, Sandia, and Mortandad Canyons. Concentrations of DO ranged from 2.03 to 5.51 mg/L. Corrected oxidation-reduction potential (Eh) values determined from field ORP measurements generally varied from 51.9 to 192.0 millivolts (mV) for those samples having temperature measurements between 9°C and 20°C that were recorded during development of well PCI-2 (Table B-1.2-1). Temperature-dependent correction factors for calculating Eh values from field ORP measurements were based on an Ag/AgCl, KCl-saturated filling solution contained in the ORP electrode. The correction factors are 213.8, 208.9, and 201.2 mV at 10.0°C, 15.0°C, and 20.0ºC, respectively. The selected Eh values associated with well PCI-2 are considered to be reliable and representative of the known relatively oxidizing conditions characteristic of perched intermediate zones beneath the Pajarito Plateau, based on analytical results for redox-sensitive solutes, including low concentrations of TOC (<0.5 mgC/L) and detectable nitrate and sulfate provided in Table B-1.2-2. Measurable concentrations of these two solutes are consistent with overall oxidizing conditions encountered at the well. Specific conductance varied from 135 to 161 microsiemens per centimeter (μS/cm), and turbidity ranged from 10 to 61.6 nephelometric turbidity units (NTUs) during well development of PCI-2 (Table B-1.2-1).

B-1.3 Analytical Results for Groundwater-Screening Samples

B-1.3.1 Tritium Analyses of Borehole PCI-2

Concentrations of tritium were less than detection (6.4 pCi/L plus 3 sigma error) in seven of the eight borehole water samples collected during drilling of PCI-2. The nondetected concentrations of tritium ranged from –3.2 to 19.2 pCi/L using the direct counting method. One sample (CAPA-09-5809) had detectable tritium at a concentration of 3.71 ± 0.29 pCi/L, with a minimum detectable activity of 0.29 pCi/L using the electrolytic enrichment method. This borehole water sample was collected on March 22, 2009, at a depth of 510 ft bgs.

B-1.3.2 Well Development

Analytical results for groundwater-screening samples collected at PCI-2 during drilling and well development are provided in Table B-1.2-2. Calcium and sodium are the dominant cations in groundwater collected from well PCI-2 during development. Dissolved concentrations of calcium and sodium ranged from 8.36 to 8.84 ppm (or mg/L) and from 19.97 to 24.25 ppm, respectively (Table B-1.2-2). Dissolved concentrations of chloride and fluoride ranged from 2.98 to 3.12 ppm and from 0.21 to 0.22 ppm, respectively, during well development. Dissolved concentrations of bromide were 0.07 ppm during well development. The maximum background concentration for dissolved bromide in perched intermediate groundwater is 0.03 mg/L (LANL 2007, 095817). Dissolved concentrations of nitrate(N) and sulfate ranged from 0.31 to 0.55 ppm and from 6.01 to 7.22 ppm, respectively, during this phase. The median background concentration for dissolved fluoride in perched intermediate groundwater is 0.12 mg/L (LANL 2007, 095817). Dissolved concentrations of chloride, nitrate(N), and sulfate exceeded Laboratory median background for perched intermediate groundwater (LANL 2007, 095817). Median background concentrations for dissolved chloride, nitrate plus nitrite(N), and sulfate in perched intermediate groundwater are 1.37 mg/L, 0.29 mg/L, and 4.08 mg/L, respectively (LANL 2007, 095817). Concentrations of TOC ranged from 0.3 to 0.4 mgC/L in groundwater-screening samples collected during development conducted at well PCI-2 (Table B-1.2-2). The median background concentration of TOC is

0.45 mgC/L for perched intermediate groundwater (LANL 2007, 095817). Concentrations of perchlorate were less than analytical detection (<0.005 ppm, IC method) in groundwater-screening samples collected from well PCI-2 during development (Table B-1.2-2).

During development conducted at well PCI-2, dissolved concentrations of iron ranged from 0.018 to 0.092 ppm (0.018 to 0.092 mg/L, 0.018 to 0.092 μg/L, or 0.018 to 0.092 ppb) when ICPOES was used (Table B-1.2-2), which did exceed the median background value of 20.0 μg/L for perched intermediate groundwater (LANL 2007, 095817). Dissolved concentrations of manganese ranged from 0.040 to 0.062 ppb, or 0.0005 ppm) for perched intermediate groundwater (LANL 2007, 095817). Dissolved concentrations of boron ranged from 0.035 to 0.045 ppm, or 35 to 45 ppb (Table B-1.2-2), at well PCI-2, which is above the maximum background value of 18.0 μg/L or ppb (0.018 ppm) for perched intermediate groundwater (LANL 2007, 095817). Concentrations of boron elevated above background at PCI-2 potentially include sources consisting of treated sewage effluent and effluent associated with preparation of high explosive compounds at Technical Areas 09 (TA-09) and TA-16. Dissolved concentrations of molybdenum slightly varied from 0.002 to 0.003 ppm, or 2 to 3 ppb (Table B-1.2-2), at well PCI-2 during development, which is above the median background value of 0.50 μg/L (0.00050 ppm) and below the maximum background value of 4.3 μg/L or ppb (0.0043 ppm) for perched intermediate depth groundwater (LANL 2007, 095817). Dissolved concentrations of nickel were 0.001 and 0.002 ppm, or 1 and 2 ppb (Table B-1.2-2), in three groundwater-screening samples collected during well development conducted at PCI-2. The background median concentration of nickel in filtered samples is 0.50 μg/L or ppb (0.0005 ppm) for perched intermediate groundwater (LANL 2007, 095817). Dissolved concentrations of zinc ranged from 0.007 to 0.022 ppm, or 7 to 22 ppb, in groundwater-screening samples collected at well TA-53-1i during development (Table B-1.2-2). The background maximum concentration of zinc in filtered samples is 19 μg/L or ppb (0.019 ppm) for perched intermediate groundwater (LANL 2007, 095817). Total dissolved concentrations of chromium were 0.002 ppm (2 ppb or 2 μg/L) at well PCI-2 during well development (Table B-1.2-2). Background mean, median, and maximum concentrations of total dissolved chromium are 0.86 μg/L or ppb (0.00086 ppm), 0.50 μg/L or ppb (0.0005 ppm), and 2.40 μg/L or ppb (0.00240 ppm), respectively, for perched intermediate groundwater (LANL 2007, 095817).

In summary, dissolved concentrations of boron exceed maximum background within perched intermediate-depth groundwater present at well PCI-2. The presence of elevated concentrations of boron at well PCI-2 suggests that a component of groundwater at this location is potentially derived from either TA-09 and/or TA-16. Long-term releases of boron within these two TAs are associated with preparation of high explosives compounds and treated sewage effluent. Groundwater at well PCI-2 is relatively oxidizing, based on corrected Eh values, measurable concentrations of DO, nitrate(N) and sulfate, and low concentrations of TOC (<0.5 mgC/L). One of the eight borehole water samples had a concentration of tritium of 3.71 ± 0.29 pCi/L, with a minimum detectable activity of 0.29 pCi/L using the electrolytic enrichment method. The presence of tritium at PCI-2 suggests that this saturated zone has experienced modern recharge postdating 1943, the time that the Laboratory started discharging tritium to the environment. The unsaturated zone above the perched intermediate depth aquifer at PCI-2 contains up to 194,783 pCi/L in pore water at a depth of 139.5 ft bgs. It is also possible that some of this tritium at PCI-2 is derived from a cosmogenic source in the absence of other contaminants.

B-2.0 REFERENCE

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

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

LANL (Los Alamos National Laboratory), May 2007. "Groundwater Background Investigation Report, Revision 3," Los Alamos National Laboratory document LA-UR-07-2853, Los Alamos, New Mexico. (LANL 2007, 095817)

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

Date	pH	Temp (°C)	DO (mg/L)	ORP[a] (mV)	Specific Conductivity (µS/cm)	Turbidity (NTU)	Purge Volume between Samples (gal.)	Cumulative Purge Volume (gal.)
04/11/09	n/r[b], bailing						230	230
04/12/09	n/r, bailing						129	359
04/13/09	n/r, pumping (add 100 gal.)						50[c]	409
04/14/09	n/r, pumping, bailing						110	519
04/15/09	n/r, pumping (add 100 gal.)						90[c]	609
04/16/09	n/r, pumping (add 50 gal.)						259[c]	868
04/17/09	7.88	9.22	3.11	-21.8, 192.0	161	61.6	59	927
	7.64	9.15	3.88	-63.7, 150.1	150	39.8	34	961
	7.58	12.99	4.80	-51.3, 157.6	144	23.7	34	995
	7.53	12.04	4.86	-58.2, 155.6	141	16.5	34	1029
	7.59	13.44	4.63	-60.8, 148.1	140	12.2	14	1043
	7.54	5.97[d]	5.24	-61.9, 156.7	144	15.7	17	1060
	7.80	9.29	4.59	-85.9, 127.9	146	20.1	17	1077
	7.60	14.09	4.27	-100.6, 108.3	144	27.2	24	1101
	7.58	14.52	4.88	-75.4, 133.5	143	25.2	17	1118
	7.52	15.23	5.26	-70.7, 138.2	142	18.3	17	1135
	7.56	11.47	5.51	-47.0, 166.8	139	21.6	42	1177
	7.67	9.58	5.28	-50.9, 162.9	142	15.4	23	1200
	n/r	n/r	n/r	n/r	n/r	n/r	13	1213
04/18/09	7.64	16.00	2.17	-119.0, 89.9	146	36.4	12	1225
	7.70	16.90	2.03	-66.9, 142.0	142	34.9	68	1293
	7.73	18.22	3.27	-81.7, 122.2	137	36.8	18	1311
	7.18	18.17	5.10	-47.4, 156.5	135	15.2	60	1371
	7.55	20.61	4.81	-39.6, 164.3	135	11.1	55	1426
	7.58	16.57	5.51	-37.7, 171.2	137	10.7	55	1481
	n/r	n/r	n/r	n/r	n/r	n/r	2	1483
04/19/09	8.46	15.54	2.70	-157.0, 51.9	154	24.6	8	1491
	7.76	18.10	3.92	-74.3, 129.6	144	37.5	52	1543
	7.67	23.43[d]	4.15	-72.8, 125.7	141	13.5	62	1605
	7.61	22.14[d]	4.03	-76.6, 127.3	137	10.3	52	1657
	7.54	19.02	4.28	-66.4, 137.5	139	10.0	71	1728
	n/r	n/r	n/r	n/r	n/r	n/r	2	1730

Table B-1.2-1 (continued)

Date	pH	Temp (°C)	DO (mg/L)	ORP[a] (mV)	Specific Conductivity (µS/cm)	Turbidity (NTU)	Purge Volume between Samples (gal.)	Cumulative Purge Volume (gal.)
04/20/09	8.00	19.46	3.36	-135.8, 68.1	159	32.3	27	1757
	7.59	20.70	3.07	-95.8, 108.1	147	29.9	43	1800
	7.52	28.56[d]	3.78	-47.7, 145.8	145	25.4	46	1846
	n/r	n/r	n/r	n/r	n/r	n/r	12	1858

Note: Cumulative purge volumes calculated for well development using average pump discharge rate of approximately 0.6 (04/17/09) and 0.5 (04/18–20/09) gpm.

[a] Eh (mV) is calculated from an Ag/AgCl-saturated KCl electrode filling solution at 10.0ºC, 15.0ºC, and 22.0ºC by adding temperature-sensitive correction factors of 213.8, 208.9, and 203.9 mV, respectively.

[b] n/r = Not recorded.

[c] Recycled water added to aid development/pumping, net amount water pumped listed in parentheses.

[d] Temperature value is not representative of perched intermediate depth groundwater. Eh (mV) is calculated from an Ag/AgCl saturated KCl electrode filling solution at 5.0ºC, 25.0 ºC, and 30.0ºC by adding temperature-sensitive correction factors of 218.6, 198.5, and 193.5 mV, respectively.

Table B-1.2-2
Analytical Results for Groundwater Screening Samples Collected at PCI-2

Sample ID	Date Collected	Date Received	Time	ER/RRES-WQH	ID	Sample 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)
CAPA-09-5762	3/22/2009	3/24/2009	9:46	09-1268	PCI-2	Borehole	510	0.001	U[a]	0.93	0.15	0.0009	0.0000	0.047	0.001	0.011	0.000	0.001	U	0.04	—[b]	1.43	0.01	0.001	U	3.33	0.005	U
CAPA-09-5782	4/17/2009	4/20/2009	11:15	09-1515	PCI-2	Well, development	512.0–525.0	0.001	U	0.002	0.000	0.0004	0.0000	0.045	0.000	0.041	0.000	0.001	U	0.07	0.30	8.61	0.04	0.001	U	3.12	0.005	U
CAPA-09-5783	4/19/2009	4/20/2009	15:30	09-1515	PCI-2	Well, development	512.0–525.0	0.001	U	0.006	0.000	0.0002	0.0000	0.038	0.000	0.047	0.001	0.001	U	0.07	0.30	8.36	0.03	0.001	U	2.98	0.005	U
CAPA-09-5784	4/20/2009	4/20/2009	10:34	09-1515	PCI-2	Well, development	512.0–525.0	0.001	U	0.004	0.000	0.0002	U	0.035	0.001	0.038	0.000	0.001	U	0.07	0.40	8.84	0.02	0.001	U	3.05	0.005	U

Table B-1.2-2 (continued)

Sample ID	Date Collected	Date Received	Time	ER/RRES-WQH	ID	Sample Type	Depth (ft)	Co rslt (ppm)	stdev (Co)	Alk-CO_3 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)
CAPA-09-5762	3/22/2009	3/24/2009	9:46	09-1268	PCI-2	Borehole	510	0.002	0.000	0.8	U	0.002	0.000	0.001	U	0.005	0.000	0.94	1.733	0.101	109	0.00029	0.00001	1.29	0.01	0.023	0.000
CAPA-09-5782	4/17/2009	4/20/2009	11:15	09-1515	PCI-2	Well, development	512.0–525.0	0.001	U	0.8	U	0.002	0.000	0.001	U	0.002	0.000	0.21	0.018	0.000	87	0.00005	U	0.34	0.00	0.017	0.000
CAPA-09-5783	4/19/2009	4/20/2009	15:30	09-1515	PCI-2	Well, development	512.0–525.0	0.001	U	0.8	U	0.002	0.000	0.001	U	0.001	0.000	0.21	0.092	0.001	83	0.00005	U	0.42	0.01	0.016	0.000
CAPA-09-5784	4/20/2009	4/20/2009	10:34	09-1515	PCI-2	Well, development	512.0–525.0	0.001	U	0.8	U	0.002	0.000	0.001	U	0.001	0.000	0.22	0.058	0.001	85	0.00005	U	0.35	0.02	0.016	0.000

Table B-1.2-2 (continued)

Sample ID	Date Collected	Date Received	Time	ER/RRES-WQH	ID	Sample Type	Depth (ft)	Mg rslt (ppm)	stdev (Mg)	Mn rslt (ppm)	stdev (Mn)	Mo rslt (ppm)	stdev (Mo)	Na rslt (ppm)	stdev (Na)	Ni rslt (ppm)	stdev (Ni)	NO2(ppm)	NO2-N rslt	NO3 ppm	NO3-N rslt	C2O4 rslt (ppm)	Pb rslt (ppm)	stdev (Pb)	Lab pH	PO4(-3) rslt (ppm)
CAPA-09-5762	3/22/2009	3/24/2009	9:46	09-1268	PCI-2	Borehole	510	0.57	0.04	0.037	0.001	0.261	0.005	45.50	0.36	0.002	0.000	0.01	0.00, U	0.01	0.00, U	0.23	0.0009	0.0000	7.84	0.01, U
CAPA-09-5782	4/17/2009	4/20/2009	11:15	09-1515	PCI-2	Well, development	512.0–525.0	1.80	0.01	0.040	0.001	0.003	0.000	19.97	0.17	0.002	0.000	0.01	0.00	0.55	0.12	0.01, U	0.0002	U	7.63	0.01, U
CAPA-09-5783	4/19/2009	4/20/2009	15:30	09-1515	PCI-2	Well, development	512.0–525.0	2.44	0.04	0.057	0.000	0.002	0.000	24.25	0.27	0.002	0.000	0.02	0.01	0.40	0.09	0.01, U	0.0002	U	7.57	0.01, U
CAPA-09-5784	4/20/2009	4/20/2009	10:34	09-1515	PCI-2	Well, development	512.0–525.0	2.24	0.02	0.062	0.001	0.002	0.000	20.68	0.10	0.001	0.000	0.03	0.01	0.31	0.07	0.01, U	0.0002	U	7.50	0.01, U

Table B-1.2-2 (continued)

Sample ID	Date Collected	Date Received	Time	ER/RRES-WQH	ID	Sample Type	Depth (ft)	Rb rslt (ppm)	stdev (Rb)	Sb rslt (ppm)	stdev (Sb)	Se rslt (ppm)	stdev (Se)	Si rslt (ppm)	stdev (Si)	SiO_2 rslt (ppm)	stdev (SiO2)	Sn rslt (ppm)	stdev (Sn)	$SO_4^{(-2)}$ rslt (ppm)	Sr rslt (ppm)	stdev (Sr)	Th rslt (ppm)	stdev (Th)	Ti rslt (ppm)	stdev (Ti)	Tl rslt (ppm)	stdev (Tl)
CAPA-09-5762	3/22/2009	3/24/2009	9:46	09-1268	PCI-2	Borehole	510	0.003	0.000	0.003	0.000	0.001	U	10.1	0.6	21.7	1.3	0.001	U	9.35	0.012	0.000	0.001	U	0.014	0.001	0.001	U
CAPA-09-5782	4/17/2009	4/20/2009	11:15	09-1515	PCI-2	Well, development	512.0–525.0	0.001	U	0.001	U	0.001	U	27.3	0.1	58.4	0.2	0.001	U	7.22	0.056	0.001	0.001	U	0.002	U	0.001	U
CAPA-09-5783	4/19/2009	4/20/2009	15:30	09-1515	PCI-2	Well, development	512.0–525.0	0.001	U	0.001	U	0.001	U	35.5	0.4	75.9	0.9	0.001	U	6.01	0.054	0.001	0.001	U	0.002	U	0.001	U
CAPA-09-5784	4/20/2009	4/20/2009	10:34	09-1515	PCI-2	Well, development	512.0–525.0	0.001	U	0.001	U	0.001	U	26.7	0.2	57.2	0.4	0.001	U	6.69	0.055	0.001	0.001	U	0.002	U	0.001	U

Table B-1.2-2 (continued)

Sample ID	Date Collected	Date Received	Time	ER/RRES-WQH	ID	Sample Type	Depth (ft)	U rslt (ppm)	stdev (U)	V rslt (ppm)	stdev (V)	Zn rslt (ppm)	stdev (Zn)	TDS (ppm)	Cations	Anions	Balance
CAPA-09-5762	3/22/2009	3/24/2009	9:46	09-1268	PCI-2	Borehole	510	0.0011	0.0000	0.002	0.000	0.009	0.000	220	2.14	2.47	-0.07
CAPA-09-5782	4/17/2009	4/20/2009	11:15	09-1515	PCI-2	Well, development	512.0–525.0	0.0006	0.0000	0.001	0.000	0.007	0.000	188	1.46	1.71	-0.08
CAPA-09-5783	4/19/2009	4/20/2009	15:30	09-1515	PCI-2	Well, development	512.0–525.0	0.0003	0.0000	0.001	0.000	0.022	0.000	206	1.69	1.62	0.02
CAPA-09-5784	4/20/2009	4/20/2009	10:34	09-1515	PCI-2	Well, development	512.0–525.0	0.0003	0.0000	0.001	0.000	0.009	0.000	185	1.54	1.66	-0.04

[a] U = Not detected.

[b] — = Not on analyte list for borehole water sample.

Appendix C

Los Alamos National Laboratory Borehole Video Logging
(on DVD included with this document)

Appendix D

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