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Completion Report for Intermediate Well CdV-16-4ip

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 intermediate perched zone well CdV-16-4ip, located within Los Alamos National Laboratory's Technical Area 16 (TA-16). This report was written in accordance with the requirements in section IV.A.3.e.iv of the March 1, 2005 (revised 2008), Compliance Order on Consent.

CdV-16-4ip was installed at the direction of the New Mexico Environment Department (NMED) as a pumping well to be used in extended pumping tests to assess the hydrogeologic properties of the perched intermediate zone beneath Consolidated Unit 16-021(c)-99 (also known as the 260 Outfall) at TA-16. The tests will assess the potential to pump and treat contaminated intermediate perched groundwater associated with the 260 Outfall.

The CdV-16-4ip borehole was drilled using fluid-assisted dual-rotary and standard air-rotary drilling methods. Drilling fluid additives included potable water and foaming agent. Injection of foam was discontinued at 603 ft below ground surface (bgs), roughly 100 ft above the anticipated top of the perched intermediate zone. The CdV-16-4ip borehole was advanced to a total depth of 1153.7 ft bgs using a combination of dual-rotary casing advance and open-hole drilling methods.

Geologic formations encountered during drilling were the Tshirege Member of the Bandelier Tuff, the Cerro Toledo interval, the Otowi Member of the Bandelier Tuff, the Guaje Pumice Bed of the Otowi Member of the Bandelier Tuff, and the Puye Formation. Perched intermediate groundwater was encountered in the Puye Formation and video logs showed strong water flow entering the borehole below 811 ft bgs before well construction.

The CdV-16-4ip perched intermediate well was completed per the NMED-approved well design with two screened intervals, an upper 63.6-ft-long screen from 815.6 to 879.2 ft bgs and a lower 31.1-ft-long screen from 1110 to 1141.1 ft bgs. The depth to water in the upper screen was 808.2 ft bgs after well completion and was 1058 ft bgs in the lower screen after well development.

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Acronyms and Abbreviations

AI	array induction
amsl	above mean sea level
APS	accelerator porosity sonde
ASTM	American Society for Testing and Materials
bgs	below ground surface
Consent Order	Compliance Order on Consent
DO	dissolved oxygen
DTW	depth to water
EES-14	Earth and Environmental Sciences Group 14
Eh	oxidation-reduction potential
EP	Environmental Programs
EPA	Environmental Protection Agency (U.S.)
FMI	formation micro-imager
HE	high explosives
HNGS	hostile-environment natural gamma-ray sonde
hp	horsepower
I.D.	inside diameter
ID	identification
LANL	Los Alamos National Laboratory
LH3	low-level tritium
MDA	material disposal area
MR	micro resistivity
MRP	magnetic resonance porosity
NAD	North American Datum
NMED	New Mexico Environment Department
NTU	nephelometric turbidity unit
O.D.	outside diameter
ORP	oxidation-reduction potential
pH	potential of hydrogen
PVC	polyvinyl chloride
Qal	alluvium
Qbo	Otowi Member of the Bandelier Tuff
Qbog	Guaje Pumice Bed of Otowi Member of the Bandelier Tuff

Qbt	Tshirege Member of the Bandelier Tuff
Qct	Cerro Toledo interval
QP	quality procedure
RCRA	Resource Conservation and Recovery Act
RDX	hexahydro-1,3,5-trinitro-1,3,5-triazine
RPF	Records Processing Facility
SOP	standard operating procedure
SU	standard unit
TA	technical area
TD	total depth
TOC	total organic carbon
Tpf	Puye Formation
VOC	volatile organic compound
WCSF	waste characterization strategy form

1.0 INTRODUCTION

This completion report summarizes the drilling, well construction, and well development for intermediate pumping well CdV-16-4ip. The report is written in accordance with the requirements in section IV.A.3.e.iv of the March 1, 2005 (revised 2008), Compliance Order on Consent (Consent Order). Well CdV-16-4ip was drilled, installed, and developed from August 4 to November 2, 2010, at Los Alamos National Laboratory (LANL or the Laboratory) for the Environmental Programs (EP) Directorate.

Well CdV-16-4ip is located within Technical Area 16 (TA-16) in the southwest corner of LANL (Figure 1.0-1). CdV-16-4ip was drilled at the direction of the New Mexico Environment Department (NMED) as a pumping well to be used for pumping tests in the intermediate perched groundwater beneath Consolidated Unit 16-021(c)-99 (260 Outfall). Data from the pumping tests, coupled with an analysis of the response in nearby wells, will be used to assess the potential to pump and treat contaminated perched groundwater. The hydrologic testing program is presented in the "Hydrologic Testing Work Plan for Consolidated Unit 16-021(c)-99" (LANL 2010, 108534).

The borehole was drilled to a total depth (TD) of 1153.7 ft below ground surface (bgs). A 5.6-in.-outside diameter (O.D.) stainless-steel well was then installed with two screened intervals, an upper 63.6-ft-long screen from 815.6 to 879.2 ft bgs and lower 31.1-ft-long screen from1110.0 to 1141.1 ft bgs in the perched intermediate zone. The composite depth to water (DTW) was measured at 932.2 ft bgs before well installation on August 17, and at 812.9 ft bgs after well installation and development on November 4. The DTW for the upper screen was 808.2 ft bgs after well installation and for the lower screen was 1058 ft bgs after well development. During drilling, cuttings samples were collected for lithologic evaluation at 5-ft intervals from ground surface to TD.

Postinstallation activities included well development, surface completion, and geodetic surveying. Future activities will include site restoration and waste management.

The information presented in this report was compiled from field reports and daily activity summaries. Records, including field reports, field logs, and survey information, are on file at the Laboratory's Records Processing Facility (RPF). This report contains brief descriptions of activities and supporting figures, tables, and appendixes completed to date associated with the CdV-16-4ip well drilling and installation project.

2.0 PRELIMINARY ACTIVITIES

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

2.1 Administrative Preparation

The following documents helped guide the implementation of the scope of work for well CdV-16-4ip:

- "Drilling Work Plan for Perched-Intermediate Pumping Well CdV-16-4ip" (LANL 2010, 109268)
- "Installation of Well CdV-16-4ip, TA-16, Los Alamos National Laboratory, Revision 1" (North Wind Inc. 2010, 111153)
- "Hydrologic Testing Work Plan for Consolidated Unit 16-021(c)-99" (LANL 2010, 108534)

- "Waste Characterization Strategy Form for Perched-Intermediate Well CdV-16-4ip, Perched-Intermediate Well Installation and Corehole Drilling" (LANL 2010, 109556)
- "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)

2.2 Site Preparation

Drill pad construction was performed by Laboratory personnel several weeks before mobilization. Mobilization activities took place between July 17 and 23, 2010, and included moving the dual-rotary drill rig, air compressors, trailers, and support vehicles to the drill site. Alternative drilling tools and construction materials were staged at the Pajarito Road laydown yard and at the CdV-16-4ip laydown yard on 340 Loop Road in TA-16.

The office trailer, generators, and general field equipment were moved on-site after mobilization of the drilling equipment. Safety barriers and signs were installed around the cuttings containment pit, along the perimeter of the work area, and on the site access road.

3.0 DRILLING ACTIVITIES

This section describes the drilling strategy and approach and provides a chronological summary of field activities conducted during the drilling of CdV-16-4ip.

3.1 Drilling Approach

The CdV-16-4ip borehole was drilled using a Schramm, Inc., T130XD Rotadrill dual-rotary drilling rig with casing rotator. The dual-rotary system allows for advancement of casing with the casing rotator while drilling with conventional air/mist/foam methods with the drill string. The Schramm T130XD drill rig was equipped with conventional 5.5-in.-O.D. dual-wall drill pipe, tricone bits, downhole hammer bits, and general drilling equipment. Auxiliary equipment included four Ingersoll Rand 1170 ft^3/min trailer-mounted air compressors, and one Sullair 1150 XHH trailer-mounted air compressor. Permanent surface conductive casing and temporary protective casing sizes used in drilling activities included 24 in., 18 in., and 12 in. Casing sizes selected ensured that the required 2-in. minimum annular thickness of the filter pack around a 5.6-in.-O.D. well, as required by the Consent Order (section X.C.3), would be met. The dual-rotary and standard-rotary (open hole) techniques used filtered compressed air and fluid-assisted air to evacuate cuttings from the borehole.

Potable water and Baroid brand AQF-2 foaming agent were used, as needed, between ground surface and 603 ft bgs (approximately 100 ft above the anticipated top of the first intermediate perched zone). The fluids were used to cool the bit and help lift cuttings from the borehole. Total amounts of drilling fluids introduced into the borehole are presented in Table 3.1-1.

3.2 Chronology of Drilling Activities

Decontamination of equipment was performed before mobilization to the site. Preparation activities and equipment mobilization took place from July 17 through 23, 2010. Following inspections, notice to proceed was received from LANL on August 3, 2010. Drilling began on August 4 at 1225 h.

Between August 4 and 5, a 24-in. casing was advanced to 60 ft bgs and set into competent rock. This was followed by placing 18-in. casing to the same depth and sealing the annulus between the two casings with bentonite chips.

From August 6 to 7, a 17-in. open borehole was drilled to 623 ft bgs. The use of foam as a drilling additive was discontinued at 603 ft bgs. From August 8 to 10, 12-in. casing was set to 625.2 ft bgs. It was necessary to clean approximately 47 ft of slough from the bottom of the borehole before the 12-in. casing could be set to depth.

Water was encountered on August 11 after drilling to a depth of 734 ft bgs. The DTW was monitored for 2.5 h, with a final stable level at 719.2 ft bgs. The borehole was blown dry for 15 min and then monitored for an additional 2 h with no measurable water detected. Drilling proceeded with stops roughly every 20 ft to check for water. It was not until a depth of 834 ft bgs that the borehole began noticeably producing water. After a 1-h recovery period, DTW was tagged at 772.3 ft bgs. Drilling continued to 934 ft bgs with a stable DTW of 777.2 ft bgs obtained at the end of the shift. On August 12, drilling reached the TD of 1153.7 ft bgs at 1651 h and a DTW of 867.4 ft bgs was recorded at the end of the shift.

Schlumberger Water Services ran a full suite of geophysical logs on August 13, 2010. LANL ran a video log and natural gamma and induction logs on August 14, 2010. Groundwater was tagged at 932.2 ft bgs on August 17 following the completion of drilling and before well installation.

During drilling, 24-h operations were conducted in two 12-h shifts, 7 d/wk. While drilling CdV-16-4ip, borehole instability was encountered from approximately 550 to 623 ft bgs in the Cerro Toledo interval.

4.0 SAMPLING ACTIVITIES

The following sections describe the cuttings and groundwater sampling activities for perched intermediate pumping well CdV-16-4ip. All sampling activities were conducted in accordance with applicable Laboratory quality procedures.

4.1 Cuttings Sampling

Cuttings samples were collected at 5-ft intervals from the borehole from ground surface to the TD of 1153.7 ft bgs. At each interval, the site geologist collected approximately 500 mL of bulk cuttings from the discharge cyclone. Cuttings were then placed in resealable plastic bags, labeled, and archived in core boxes. Smaller size fractions (>#10 and >#35 mesh) were sieved from the bulk cuttings and placed in chip trays along with unsieved (whole rock) cuttings. Samples were recovered from more than 99% of the borehole; samples were not recovered from 285 to 290 ft bgs. Radiation control technicians screened cuttings after 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.

CdV-16-4ip stratigraphy is summarized in section 5.1 of this report and detailed lithology is provided in Appendix A.

4.2 Water Sampling

According to the drilling work plan, perched groundwater samples were not collected during borehole drilling. However, 19 groundwater samples were collected during well development.

Three samples were collected from the upper screened interval during development and analyzed for total organic carbon (TOC). The final sample collected from the upper screen, on August 31, 2010, was also analyzed for metals, cations, and anions.

Seven samples were collected from the lower screened interval during development from September 12 to 18, 2010, and analyzed for TOC; the final sample was also analyzed for metals, cations, and anions. During this period of lower screen well development, the packer isolating the two screened zones was insufficiently inflated, which allowed high explosives (HE) consitutents in the upper perched zone to enter the lower perched interval. Additional pumping of the lower zone was conducted from October 21 to 26 and from October 30 to November 2, 2010, in an attempt to remove the HE compounds. Four samples were collected between October 21 and 26, 2010, for HE analyses; the final sample was also analyzed for TOC. Five samples were collected from October 30 to November 2, 2010, for HE analyses; the final sample was also analyzed for TOC.

Table 4.2-1 presents a summary of screening samples collected during development of CdV-16-4ip. Groundwater chemistry and field water-quality parameters are discussed in Appendix B.

5.0 GEOLOGY AND HYDROGEOLOGY

A brief description of the geologic and hydrogeologic features encountered at CdV-16-4ip is presented below. The Laboratory’s geology task leader and site geologists examined cuttings to determine geologic contacts and hydrogeologic conditions. Drilling observations, video logging, and water-level measurements were used to characterize groundwater occurrences.

5.1 Stratigraphy

The stratigraphy observed in the CdV-16-4ip borehole is based on lithologic descriptions of cuttings samples collected from the discharge cyclone, borehole geophysical logs, and video logs. Stratigraphy is described below in order of youngest to oldest geologic units. Figure 5.1-1 illustrates the stratigraphy at CdV-16-4ip. A detailed lithologic log based on binocular microscope examination and analysis of drill cuttings is presented in Appendix A.

Unit 4, Tshirege Member of the Bandelier Tuff, Qbt 4 (0 to 50 ft bgs)

Unit 4 of the Tshirege Member of the Bandelier Tuff occurs from 0 to 50 ft bgs. Unit 4 consists of white to light pinkish gray and pink partly welded to nonwelded, crystal- and lithic-rich tuff.

Unit 3t, Tshirege Member of the Bandelier Tuff, Qbt 3t (50 to 112 ft bgs)

Unit 3t of the Tshirege Member of the Bandelier Tuff occurs from 50 to 112 ft bgs. Unit 3t consists of reddish gray to gray partly welded to densely welded, crystal- and lithic-rich devitrified tuff.

Unit 3, Tshirege Member of the Bandelier Tuff, Qbt 3 (112 to 180 ft bgs)

Unit 3 of the Tshirege Member of the Bandelier Tuff occurs from 112 to 180 ft bgs. Unit 3 consists of reddish gray to gray and light gray partly welded to moderately welded, crystal- and lithic-rich devitrified tuff.

Unit 2, Tshirege Member of the Bandelier Tuff, Qbt 2 (180 to 315 ft bgs)

Unit 2 of the Tshirege Member of the Bandelier Tuff occurs from to 180 to 315 ft bgs. Unit 2 consists of light reddish gray to gray moderately welded to densely welded, crystal-rich devitrified and vapor-phase altered tuff.

Unit 1v, Tshirege Member of the Bandelier Tuff, Qbt 1v (315 to 330 ft bgs)

Unit 1v of the Tshirege Member of the Bandelier Tuff occurs from 315 to 330 ft bgs. Unit 1v consists of pale red to gray/light gray partly welded to nonwelded, crystal-rich devitrified tuff.

Unit 1g, Tshirege Member of the Bandelier Tuff, Qbt 1g (330 to 340 ft bgs)

Unit 1g of the Tshirege Member of the Bandelier Tuff occurs from 330 to 340 ft bgs. Unit 1g consists of pinkish gray to light brown poorly welded to nonwelded vitric pumice and tuff.

Cerro Toledo Interval, Qct (340 to 628 ft bgs)

The Cerro Toledo interval occurs from 340 to 628 ft bgs and consists of light gray/pale brown to very pale brown and reddish gray moderately sorted tuffaceous sedimentary deposits separating the Tshirege and Otowi Members of the Bandelier Tuff. The deposits are predominantly reworked tuff with some silts, sands, granules, and gravels derived from Tschicoma dacites in the Sierra de los Valles highlands west of the Pajarito Plateau.

Otowi Member of the Bandelier Tuff, Qbo (628 to 792 ft bgs)

The Otowi Member Bandelier Tuff occurs from 628 to 792 ft bgs and consists of very pale brown to light gray glassy, pumiceous, nonwelded to partly welded ash-flow tuff with lithic clasts and intermediate-composition volcanic rocks.

Guaje Pumice Bed of the Otowi Member of the Bandelier Tuff, Qbog (792 to 800 ft bgs)

The Guaje Pumice Bed occurs from 792 to 800 ft bgs. The pumice bed, white to reddish gray, contains pumice fragments with subordinate amounts of volcanic lithics and quartz and sanidine phenocrysts.

Puye Formation, Tpf (800 to 1153.7 ft bgs)

The Puye Formation occurs from 800 to 1153.7 ft bgs. The formation consists of very pale brown/reddish gray to gray volcaniclastic sediments with poorly sorted subangular to subrounded boulders, cobbles, gravels, sands, and silts.

5.2 Groundwater

On August 11, 2010, groundwater was first detected while drilling at 734 ft bgs in the Otowi Member of the Bandelier Tuff; the borehole was monitored for 2.5 h and the DTW was measured at 719.2 ft bgs. However, after blowing out the borehole for 15 min and monitoring for an additional 2 h, measurable water was no longer present.

A sustainable productive water-bearing zone was first noted at a depth of 834 ft bgs in the Puye Formation; DTW rose to 772.3 ft bgs after 1 h. A strong water flow into the borehole was noted at 811 ft bgs on the borehole video log obtained at borehole TD.

After reaching a depth of 934 ft bgs, a stable DTW of 777.2 ft bgs was measured. The composite DTW in the open borehole at TD before well construction was 932.2 ft bgs. On November 4, following well development, DTW of the upper and lower screened zones was 812.9 ft bgs and 1058 ft bgs, respectively.

A thorough discussion of the two perched intermediate groundwater zones at CdV-16-4ip is presented in the Final Well Design in Appendix C.

6.0 BOREHOLE LOGGING

The following sections describe the video and geophysical logging conducted at CdV-16-4ip. A summary of all logging is provided in Table 6.0-1.

6.1 Video Logging

LANL personnel ran a video log of the CdV-16-4ip borehole on August 14, 2010, from ground surface to 1151 ft bgs. Details of this log are provided in Table 6.0-1. The video log is provided on two DVDs as Appendix D of this report.

6.2 Geophysical Logging

On August 13, 2010, Schlumberger ran a full suite of geophysical logs in the CdV-16-4ip borehole. The logs were run through casing from ground surface to 626 ft bgs and open borehole from 626 to 1151 ft bgs. These geophysical logs included array induction (AI), magnetic resonance porosity (MRP), hostile-environment natural gamma-ray sonde (HNGS) and caliper logs, accelerator porosity sonde (APS), micro resistivity (MR), and formation micro-imager (FMI). The Schlumberger geophysical logging report is on the CD included as Appendix E of this report.

LANL personnel ran natural gamma and induction logs in the CdV-16-4ip borehole on August 14, 2010, from ground surface to 1151 ft bgs (Table 6.0-1).

7.0 WELL INSTALLATION

The CdV-16-4ip well was installed between August 17 and 23, 2010. The following sections summarize the well design and well construction activities.

7.1 Well Design

The CdV-16-4ip well was designed in accordance with the Drilling Work Plan (LANL 2010, 109268) and a final well design developed after TD was reached (Appendix C). The well was designed with two screened intervals to monitor perched intermediate groundwater quality and water levels in the Puye Formation. The 63.6-ft-long upper screen was installed from 815.6 to 879.2 ft bgs and the 31.1-ft-long lower screen was installed from 1110 to 1141.1 ft bgs with a 4.9-ft stainless-steel sump below the bottom of the lower screen.

7.2 Well Construction

The CdV-16-4ip well was constructed of 5.0-in.-inside diameter (I.D.)/5.6-in.-O.D. passivated type 304 stainless-steel threaded casing fabricated to American Society for Testing and Materials (ASTM) standard A312. The screened intervals consist of 63.6-ft and 31.1-ft lengths of 5.0-in.-I.D. rod-based, 0.020-in. slot, wire-wrapped well screen. Compatible external stainless-steel couplings (also passivated type 304 stainless steel fabricated to ASTM A312 standards) were used to join all individual casing and screen sections. Casing and the screens were provided by the Laboratory and were steam pressure washed on-site before installation. A 2.5-in.-O.D. steel, flush-threaded tremie pipe string, also decontaminated before use, was used to deliver annular fill materials and potable water downhole during well construction.

Decontamination of the stainless-steel well casing, screens, and tremie pipe, along with mobilization of initial well construction materials to the site, took place from August 14 to 16 while the borehole water level was being monitored and preparation for geophysical logging was under way. The NMED-approved final well design was received on August 17, 2010.

On August 17 at 2245 h, the drilling crew began installing 5.0-in.-I.D. stainless-steel well casing and screens into the borehole. Each casing section was threaded to the string using stainless-steel couplings. The well casing was set on August 18 with the bottom of the well set at 1146.0 ft bgs. The bottom of the borehole was measured at 1150.5 ft bgs, indicating 3.2 ft of formational slough was present in the bottom of the borehole.

The well was constructed from August 17 to 23, 2010, with two screened intervals as specified in the well design. The top of the 63.6-ft-long upper screen was set at 815.6 ft bgs and the top of the 31.1-ft-long lower screen was set at 1110 ft bgs. A 4.9-ft stainless-steel sump was placed below the bottom of the lower screen. Stainless-steel centralizers (4 sets of 4) were welded to the well casing at 813 and 882 ft bgs, above and below the upper screen, and at 1108 and 1143 ft bgs, above and below the lower screen. Figure 7.2-1 presents an as-built schematic showing construction details for the completed well.

A water line and materials pump were hooked up to the tremie pipe to deliver the annular fill materials. Bentonite backfill was placed below and around the well sump from 1150.5 to 1145.1 ft bgs. This bottom seal consisted of 0.375-in. bentonite chips with a volume of 4.0 ft^3. The primary filter pack for the lower screen consisted of 25.5 ft^3 of 10/20 clean silica sand from 1145.1 to 1105.3 ft bgs. Following emplacement of the filter pack, the lower screened interval was swabbed and the borehole was surged to promote proper settling and compaction. The fine sand transition collar (4.5 ft^3 of 20/40 clean silica sand) was placed from 1105.3 to 1098.3 ft bgs (Figure 7.2-1).

A bentonite seal was placed above the lower screen sand pack from 1098.3 to 884.9 ft bgs, 5.7 ft below the upper screen. This intermediate seal consisted of 123.7 ft^3 of 0.375-in. bentonite chips.

The primary 10/20 clean silica sand filter pack was placed around the upper screened interval from 884.9 to 809.8 ft bgs. Backfilling of this zone required 63% more material than the calculated volume (43.0 ft^3 calculated, 71.0 ft^3 used). Following emplacement of the filter pack, the upper screened interval was swabbed and the borehole was surged to promote proper setting and compaction before installation of the 20/40 clean silica fine sand transition collar from 809.8 to 805.7 ft bgs. Backfilling of this zone required 88% more material than had been calculated (2.4 ft^3 calculated, 4.5 ft^3 used). The primary filter pack and fine sand transition collar for the upper screen were set within the poorly consolidated volcaniclastic sediments of the Puye Formation, which have a tendency to wash out and form voids during drilling. A review of the video log shows large voids at 804 to 813 ft bgs (video resolution degenerates after 813 ft bgs).

A bentonite seal was placed above the transition sand from 805.7 to 59.3 ft bgs. The seal consists of 0.375-in.bentonite chips. The quantity of materials used in this zone was 882.9 ft^3.

The final surface seal was placed from 59.3 ft bgs to 3 ft bgs on August 23 using a 100 wt% Type I Portland cement. The difference between the actual volume used (94.8 ft^3) inside of the 24-in. casing and the calculated volume (167.8 ft^3) was 44% and is likely due to the occurrence of standing water on top of the bentonite seal. The standing water could have mixed with the pumped grout mixture, increasing the yield of the grout. The well was completed per NMED criteria on August 23 at 0922 h.

On August 24 and 25, 2010, the 24-in. surface casing was over-drilled from 0 to 20 ft bgs, the annular space between the outside of the surface casing and the borehole wall was backfilled with Portland cement to 3 ft bgs.

8.0 POSTINSTALLATION ACTIVITIES

Following well installation at CdV-16-4ip, well development was performed, the wellhead and surface pad were constructed, and a geodetic survey was performed. Following the final disposition of contained drill cuttings and groundwater, site restoration activities will be completed according to the NMED-approved waste-disposal decision trees.

8.1 Well Development

Well development for both screened intervals was conducted from August 27 to November 2, 2010. A bridge packer was installed to separate the two screened intervals before well development. Well development began with swabbing and bailing to promote settling and removal of fines from the sand filter pack. Bailing continued until water clarity visibly improved. Final development was accomplished using a submersible pump.

The swabbing tool used was a 4.5-in.-diameter, 1-in.-thick rubber disc attached to a weighted steel rod. The swabbing tool was lowered by wireline using a Semco S15000 work-over rig and drawn repeatedly across the screened intervals. The bailing tool was a 4-in.-O.D. by 11.0-ft-long carbon-steel bailer with a total capacity of approximately 7 gal.

Development was completed at each screened interval with a 10-horsepower (hp), 4-in.-diameter Grundfos submersible pump.

Upper screen

A total of 229 gal. of water was bailed from the upper screen at the start of development. During the pumping phase of development, the submersible pump was set at multiple depths over the screened interval. The upper screen was pumped at an average rate of 5.6 gpm over 4 d and a total of 11,145 gal. was removed from the upper perched zone.

Lower screen

Swabbing and bailing of the lower screen began on September 9, 2010, and 84 gal. were bailed. Well development with the submersible pump was initially conducted between September 9 and 18, 2010. However, transducer data showed that the bridge packer previously used had not been inflated properly. Hexahydro-1,3,5-trinitro-1,3,5-triazine (RDX) data collected on September 18, 2010, confirmed that groundwater cross flow from the upper screen to the lower screen had occurred. Therefore, after the packer was properly inflated to 220 psi, pumping continued from October 21 to 26 in an attempt to remove the RDX contamination in the lower zone. RDX analysis was conducted daily during this period of additional pumping. RDX concentrations steadily declined, and further pumping was conducted from October 30 to November 2 in an effort to continue to reduce RDX levels in the lower zone. An RDX value of 25 ppb was achieved at the end of the last phase of well development on November 2, 2010, and at that point pumping ceased (see Appendix B for details).

The lower screen was pumped at an average rate of 6.6 gpm, and a total of 56,629 gal. was purged from the lower perched zone in CdV-16-4ip.

Water use in the regional aquifer: volumes introduced versus removed

Approximately 23, 260 gal. of potable water were introduced below 800 ft bgs (the approximate static water level) at CdV-16-4ip; 5200 gal. were used during drilling and 18,060 gal. were used during well construction. Water used within the upper screen filter pack from 809.8 to 884.9 ft bgs during drilling and well construction totaled 2727 gal. Water used within the lower screen filter pack from 1105.3 to 1145.1 ft bgs during drilling and well construction totaled 2249 gal. A total of 67,774 gal. was removed from the screened intervals between 815.6 to 879.2 ft bgs and 1110 to 1141.1 ft bgs during well development.

8.1.1 Well Development Field Parameters

The field parameters of turbidity, temperature, potential of hydrogen (pH), dissolved oxygen (DO), oxidation-reduction potential (ORP), and specific conductance were monitored by means of a flow-through cell at CdV-16-4ip during the pumping stage of well development at each screened interval. In addition, water samples were collected for TOC analysis from both screens. TOC values less than 2.0 ppm and turbidity less than 5 nephelometric turbidity units (NTU) indicate the well has been developed adequately. See Appendix B for a discussion of field parameters measured during development at each screen.

Final field parameter measurements at the end of development for the upper screen were as follows: pH was 6.9, temperature was 12.0°C, specific conductance was 127 µS/cm, and turbidity was 9.4 NTU. The final TOC concentration was 0.58 mg/L.

Final field parameter measurements at the end of development for the lower screen were as follows: pH was 7.2, temperature of 11.4°C, specific conductance of 100 µS/cm, and turbidity was 0.3 NTU. The final TOC concentration was 0.51 mg/L.

Table B-1.2-1 presents all field parameters and discharge volumes recorded during development.

8.2 Aquifer Testing

Aquifer testing was not conducted at CdV-16-4ip after well completion because the well will be used for large-scale aquifer tests as described in the “Hydrologic Testing Work Plan for Consolidated Unit 16-021(c)-99” (LANL 2010, 108534).

8.3 Dedicated Sampling System Installation

A dedicated sampling system was not installed at this time at CdV-16-4ip because its primary purpose is as a pumping well for large-scale aquifer tests to assess the hydrologic properties of the two perched zones.

8.4 Wellhead Completion

A reinforced concrete surface pad, 10 ft ×10 ft × 6.0 in. thick, was installed at the CdV-16-4ip wellhead. The concrete pad was slightly elevated above ground surface and crowned to promote runoff. The pad will provide long-term structural integrity for the well. A brass monument marker was embedded in the northwest corner of the pad. A 16-in.-O.D. steel protective casing with a locking lid was installed around the stainless-steel well riser. A 0.5-in. weep hole was drilled near the base of the protective casing to prevent water accumulation inside the protective casing. Four steel bollards, covered by high-visibility plastic sleeves, were set at the outside edges of the pad to protect the well from accidental vehicle damage. They are designed for easy removal to allow access to the well. Details of the wellhead completion are presented in Figure 8.4-1a. A summary of CdV-16-4ip technical notes is presented in Figure 8.4-1b.

8.5 Geodetic Survey

A licensed professional land surveyor conducted a geodetic survey on October 14, 2010 (Table 8.5-1). The survey data conform to Laboratory Information Architecture project standards IA-CB02, “GIS Horizontal Spatial Reference System,” and IA-D802, “Geospatial Positioning Accuracy Standard for A/E/C and Facility Management.” All coordinates are expressed relative to New Mexico State Plane Coordinate System Central Zone 83 (North American Datum [NAD] 83); elevation is expressed in feet above mean sea level (amsl) using the National Geodetic Vertical Datum of 1929. Survey points included ground-surface elevation near the concrete pad, the top of the monument marker in the concrete pad, the top of the well casing, and the top of the protective casing. The survey data are provided in Table 8.5-1 and the location survey report is provided as Appendix F.

8.6 Waste Management and Site Restoration

Waste generated from the CdV-16-4ip project includes drilling fluids, purged groundwater, drill cuttings, decontamination water, and contact waste. A summary of the waste characterization samples collected during drilling, construction, and development of the CdV-16-4ip 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 Perched Intermediate Well CdV-16-4ip” (LANL 2010, 109556).

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

Cuttings produced during drilling are anticipated to be land-applied after a review of associated analytical results per the WCSF and ENV-RCRA-QP-011.1. If the drill cuttings do not meet the criteria for land application, they will be disposed at an authorized facility.

Decontamination fluid used for cleaning the drill rig and equipment is currently containerized. The fluid waste was sampled and will be disposed of at an authorized facility. Characterization of contact waste will be based upon acceptable knowledge, pending analyses of the waste samples collected from the drill fluids, drill cuttings, purge water, and decontamination fluid.

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

9.0 DEVIATIONS FROM PLANNED ACTIVITIES

Drilling and sampling at CdV-16-4ip were performed as specified in “Installation of Well CdV-16-4ip, TA-16, Los Alamos National Laboratory, Revision 1” (North Wind, Inc. 2010, 111153).

10.0 ACKNOWLEDGMENTS

Layne Christensen drilled the CdV-16-4ip borehole and installed the well.

Laboratory personnel ran downhole video, natural gamma logging, and induction logging equipment.

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

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

11.0 REFERENCES AND MAP DATA SOURCES

11.1 References

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

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

LANL (Los Alamos National Laboratory), 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), February 2010. “Hydrologic Testing Work Plan for Consolidated Unit 16-021(c)-99,” Los Alamos National Laboratory document LA-UR-10-0404, Los Alamos, New Mexico. (LANL 2010, 108534)

LANL (Los Alamos National Laboratory), April 2010. “Drilling Work Plan for Perched-Intermediate Pumping Well CdV-16-4ip,” Los Alamos National Laboratory document LA-UR-10-2147, Los Alamos, New Mexico. (LANL 2010, 109268)

LANL (Los Alamos National Laboratory), May 19, 2010. “Waste Characterization Strategy Form for Perched-Intermediate Well CdV-16-4ip, Perched-Intermediate Well Installation and Corehole Drilling,” Los Alamos, New Mexico. (LANL 2010, 109556)

North Wind Inc., July 26, 2010. “Installation of Well CdV-16-4ip, TA-16, Los Alamos National Laboratory, Revision 1,” plan prepared for Los Alamos National Laboratory, Los Alamos, New Mexico. (North Wind, Inc., 2010, 111153)

11.2 Map Data Sources

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

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

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

Inactive Outfalls; Los Alamos National Laboratory, Water Quality and Hydrology Group of the Environmental Stewardship Division at Los Alamos National Laboratory Los Alamos New Mexico; 01 September 2003.

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

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

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

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

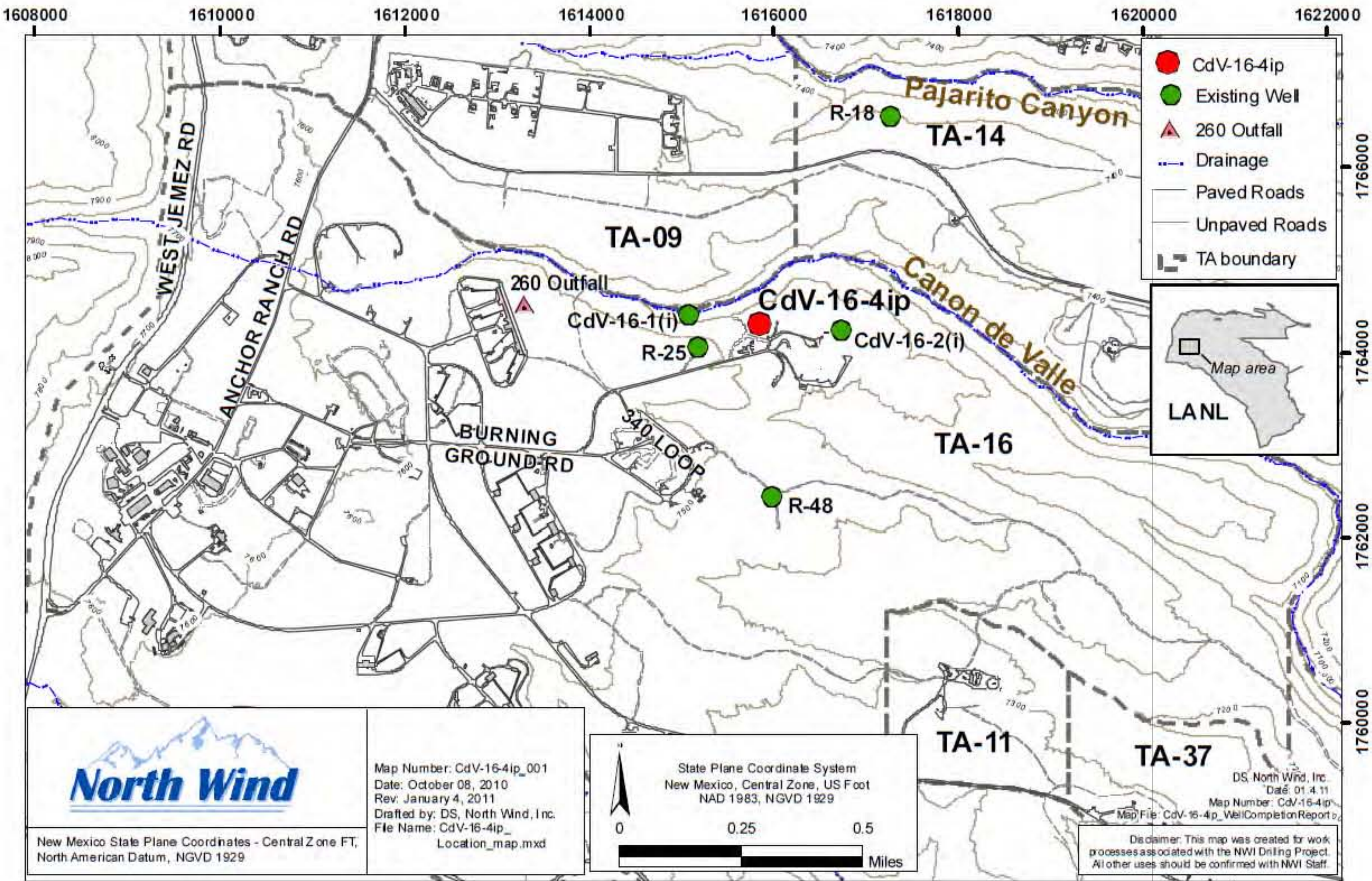

Figure 1.0-1 Well CdV-16-4ip location map

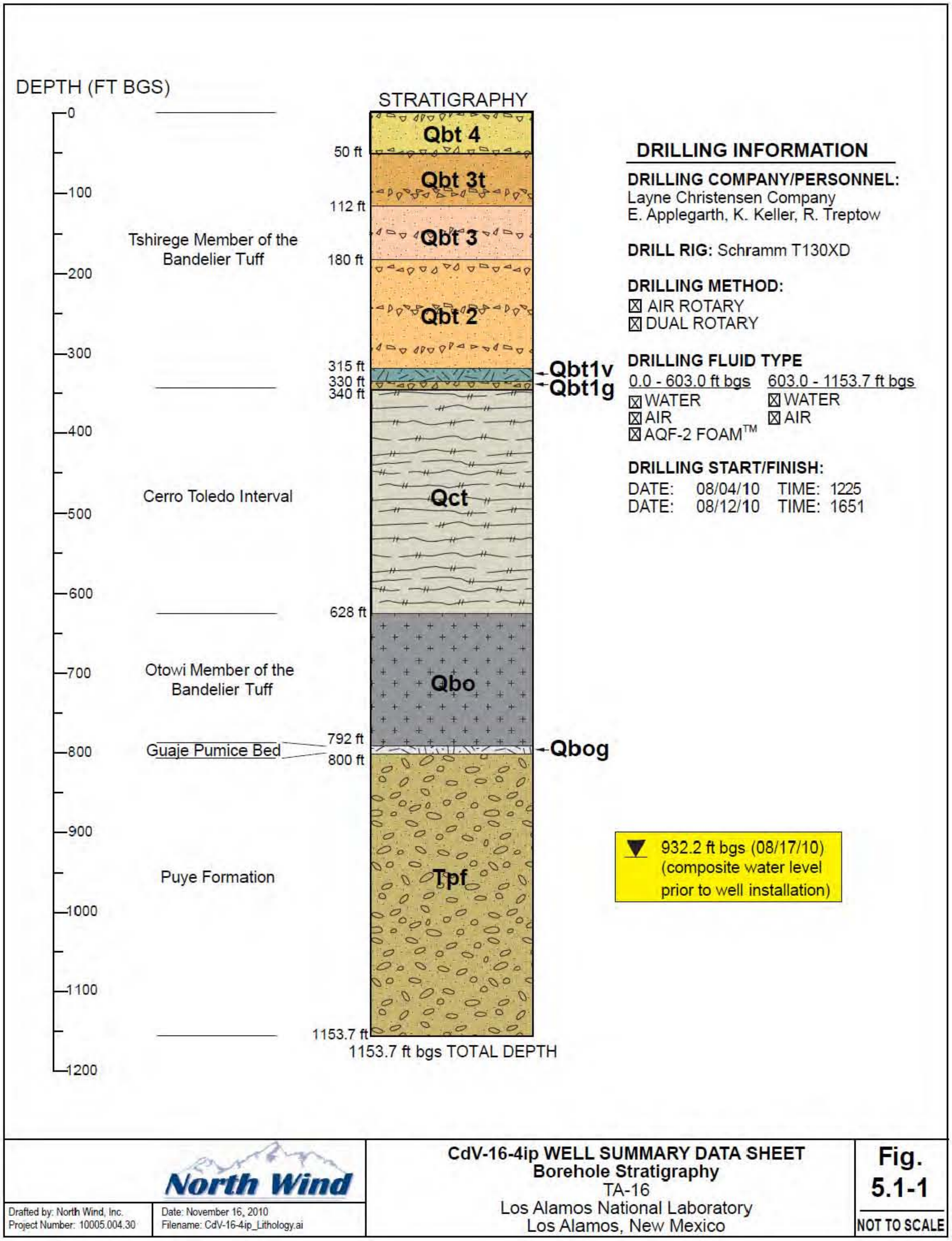

Figure 5.1-1 CdV-16-4ip borehole stratigraphy

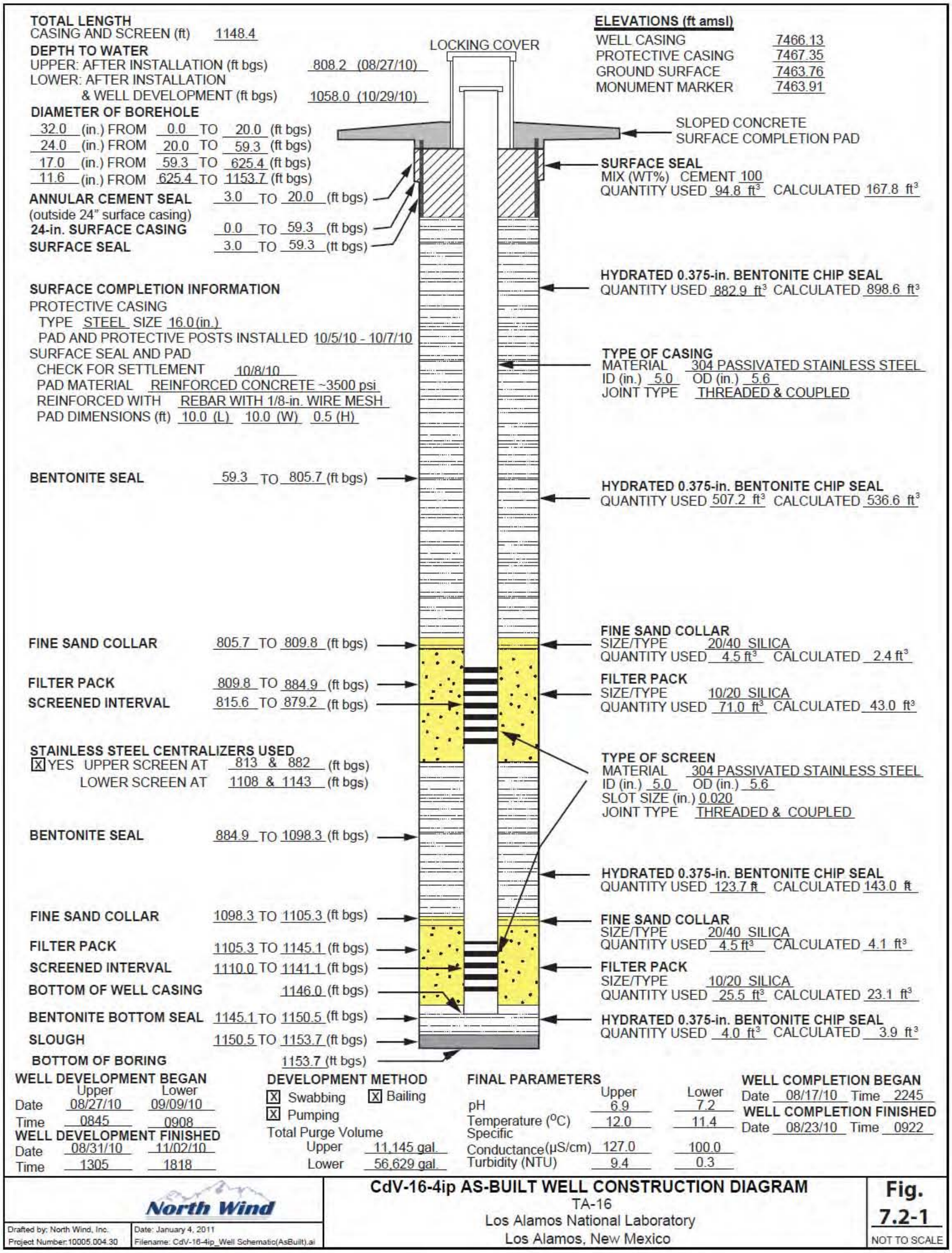

Figure 7.2-1 Cdv-16-4ip as-built well construction diagram

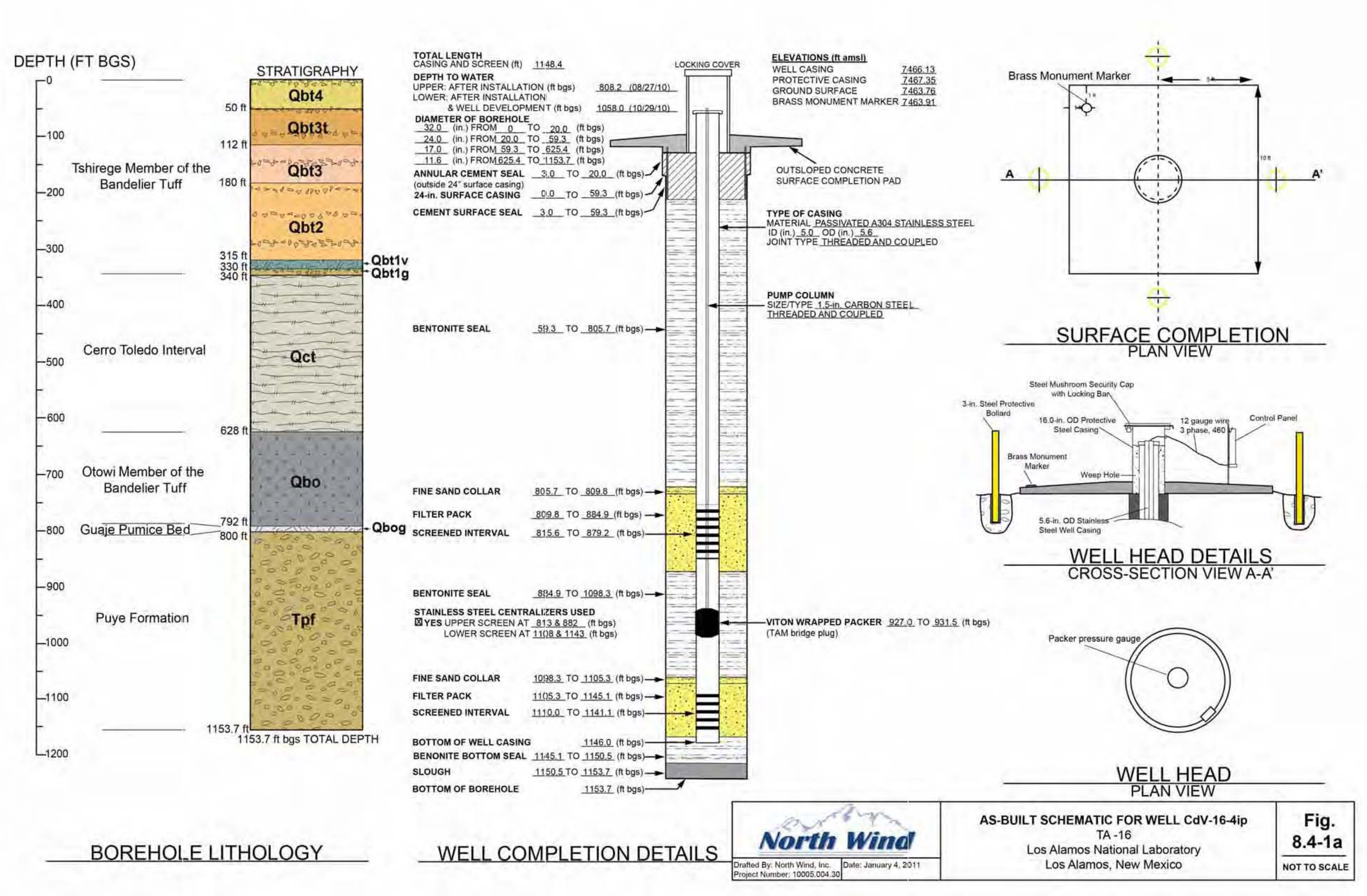

Figure 8.4-1a As-built schematic for well CdV-16-4ip

CdV-16-4ip TECHNICAL NOTES

SURVEY INFORMATION[1]

Brass Marker

Northing:	1764195.74 ft
Easting	1615587.07 ft
Elevation	7463.91 ft amsl

Well Casing

Northing:	1764190.43 ft
Easting:	1615590.17 ft
Elevation:	7466.13 ft amsl

BOREHOLE GEOPHYSICAL LOGS

LANL natural gamma and array induction logs
Schlumberger: array induction, magnetic resonance porosity, hostile natural gamma ray spectroscopy and caliper logs, accelerator porosity sonde, micro resistivity, and formation micro-imager.

DRILLING INFORMATION

Drilling Company
Layne Christensen Company

Drill Rig
Schramm T130XD

Drilling Methods
Fluid-assisted air rotary
Fluid-assisted dual rotary

Drilling Fluids
Air
AQF-2 Foam (to 603.0 ft bgs)
Potable water

MILESTONE DATES

Drilling

Start:	08/04/2010
Finish:	08/12/2010

Well Completion

Start:	08/17/2010
Finish:	08/23/2010

Well Development

Start:	08/27/2010
Finish:	11/02/2010

WELL DEVELOPMENT

Development Methods
Performed swabbing, bailing, and pumping
Volume Purged:
Upper Screen: 11,145 gal.
Lower Screen: 56,629 gal.

Final Parameters

	Upper Screen	Lower Screen
pH:	6.9	7.2
Temperature:	12.0ºC	11.4ºC
Specific Conductance:	127 µS/cm	100 µS/cm
Turbidity	9.4 NTU	0.3 NTU

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

North Wind
Drafted by: North Wind, Inc. Project Number:10005.004.30
Date: January 4, 2011

CdV-16-4ip TECHNICAL NOTES
TA-16
Los Alamos National Laboratory
Los Alamos, New Mexico

Fig. 8.4-1b

Figure 8.4-1b Technical notes for well CdV-16-4ip

Table 3.1-1
Fluid Quantities Used during CdV-16-4ip Drilling and Well Construction

Date	Water (gal.)	Cumulative Water (gal.)	AQF-2 Foam (gal.)	Cumulative AQF-2 Foam (gal.)
Drilling				
08/04/10	1500	1500	n/a*	n/a
08/05/10	2000	3500	n/a	n/a
08/06/10	3900	7400	3	3
08/07/10	4900	12,300	35	38
08/10/10	500	12,800	n/a	n/a
08/11/10	2200	15,000	n/a	n/a
08/12/10	3000	18,000	n/a	n/a
Well Construction				
08/18/10	5410	5410	n/a	n/a
08/19/10	1200	6610	n/a	n/a
08/20/10	11.450	18,060	n/a	n/a
08/21/10	15,200	33,260	n/a	n/a
08/22/10	18,100	51,360	n/a	n/a
08/23/10	376	51,736	n/a	38
Total Water Volume (gal.)				
CdV-16-4ip	69,736 gal.			

* n/a = Not applicable.

Table 4.2-1
Summary of Groundwater Screening Samples Collected during Drilling and Well Development of Well CdV-16-4ip

Location Identification (ID)	Sample ID	Date Collected	Collection Depth (ft bgs)	Sample Type	Analysis
Well Development					
CdV-16-4ip	GW4ip-10-24993	08/29/10	880 (upper screen)	Groundwater (pump lift)	TOC
CdV-16-4ip	GW4ip-10-24994	08/30/10	840 (upper screen)	Groundwater (pump lift)	TOC
CdV-16-4ip	GW4ip-10-24995	08/31/10	880 (upper screen)	Groundwater (pump lift)	TOC, metals/anions
CdV-16-4ip	GW4ip-10-26049	09/12/10	1135 (lower screen)	Groundwater (pump lift)	TOC
CdV-16-4ip	GW4ip-10-26050	09/13/10	1135 (lower screen)	Groundwater (pump lift)	TOC
CdV-16-4ip	GW4ip-10-26051	09/14/10	1125 (lower screen)	Groundwater (pump lift)	TOC
CdV-16-4ip	GW4ip-10-26542	09/15/10	1125 (lower screen)	Groundwater (pump lift)	TOC
CdV-16-4ip	GW4ip-10-26543	09/16/10	1115 (lower screen)	Groundwater (pump lift)	TOC
CdV-16-4ip	GW4ip-10-26544	09/17/10	1135 (lower screen)	Groundwater (pump lift)	TOC
CdV-16-4ip	GW4ip-10-26056	09/18/10	1135 (lower screen)	Groundwater (pump lift)	TOC, metals/anions
CdV-16-4ip	GW4ip-11-1112	10/21/10	1135 (lower screen)	Groundwater (pump lift)	HE
CdV-16-4ip	GW4ip-11-1113	10/22/10	1135 (lower screen)	Groundwater (pump lift)	HE
CdV-16-4ip	GW4ip-11-1115	10/24/10	1135 (lower screen)	Groundwater (pump lift)	HE
CdV-16-4ip	GW4ip-11-1415	10/26/10	1135 (lower screen)	Groundwater (pump lift)	HE, TOC
CdV-16-4ip	GW16-11-1532	10/30/10	1135 (lower screen)	Groundwater (pump lift)	HE
CdV-16-4ip	GW16-11-1533	10/30/10	1135 (lower screen)	Groundwater (pump lift)	HE
CdV-16-4ip	GW16-11-1534	10/31/10	1135 (lower screen)	Groundwater (pump lift)	HE
CdV-16-4ip	GW16-11-1535	11/01/10	1135 (lower screen)	Groundwater (pump lift)	HE
CdV-16-4ip	GW16-11-1943	11/02/10	1135 (lower screen)	Groundwater (pump lift)	HE, TOC

Table 6.0-1
CdV-16-4ip Video and Geophysical Logging Runs

Date	Type of Log	Depth (ft bgs)	Description
08/13/10	Schlumberger geophysical logs	0-1151	Schlumberger full geophysical log suite run in CdV-16-4ip: AI, MRP, HNGS, APS, MR, and FMI. All logs were run through a cased borehole from ground surface to 626 ft bgs and open borehole from 626 to 1151 ft bgs.
08/14/10	Video	0-1151	Video shows bottom of 12-in. casing at 626 ft bgs, the contact between Qbog and Tpf at 800 ft bgs, and strong water flow into borehole at 811 ft bgs.
08/14/10	Natural gamma	0-1151	LANL natural gamma log run from ground surface to 1151 ft bgs.
08/14/10	Induction	0-1151	LANL induction tool run from ground surface to 1151 ft bgs.

Table 7.2-1
CdV-16-4ip Annular Fill Materials

Material	Volume (ft^3)
Surface seal: 100 wt% Portland cement	94.8
Upper seal: 0.375-in. bentonite chips	882.9
Transition sand collar: 20/40 silica sand	4.5
Primary filter pack (upper screen): 10/20 silica sand	71.0
Inter-screen seal: 0.375-in. bentonite chips	123.7
Transition sand collar: 20/40 silica sand	4.5
Primary filter pack (lower screen): 10/20 silica sand	25.5
Lower seal: 0.375-in. bentonite chips	4.0

Table 8.5-1
CdV-16-4ip Survey Coordinates

Identification	Northing	Easting	Elevation
Cdv-16-4ip brass monument marker	1764195.74	1615587.07	7463.91
CdV-16-4ip top of 16.0 in. protective casing	1764190.50	1615590.17	7467.35
CdV-16-4ip top of well casing	1764190.43	1615590.17	7466.13
Cdv-16-4ip ground surface	1764184.46	1615576.60	7463.76

Note: All coordinates are expressed as New Mexico State Plan Coordinate System Central Zone 83 (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 CdV-16-4ip

Sample ID/Event ID	Date, Time Collected	Description	Sample Matrix
WSTCDV-10-24965/3017	08/04/10, 1630	Trip blank	Solid
WSTCDV-10-24968/3017	08/04/10, 1630	Volatile organic compound (VOC) cuttings	Solid
WSTCDV-10-24966/3017	08/07/10, 1145	Trip blank	Solid
WSTCDV-10-24969/3017	08/07/10, 1145	VOC cuttings	Solid
WSTCDV-10-24967/3017	08/12/10, 1651	Trip blank	Solid
WSTCDV-10-24970/3017	08/12/10, 1651	VOC cuttings	Solid
WSTCDV-10-25469/3036	08/17/10, 1130	Decontamination water	Liquid
WSTCDV-10-25468/3036	08/17/10, 1130	Trip blank	Liquid
WSTCDV-10-25520/3040	08/26/10, 1435	Trip blank	Solid
WSTCDV-10-25521/3040	08/26/10, 1435	Drill cuttings	Solid
WSTCDV-10-25648/3447	08/30/10, 1250	Trip blank	Liquid
WSTCDV-10-25649/3447	08/30/10, 1250	Decontamination water	Liquid
WSTCDV-10-26065/3059	09/01/10, 1115	Trip blank	Liquid
WSTCDV-10-26066/3059	09/1/10, 1115	Decontamination water	Liquid
WSTCDV-10-25512/3037	09/01/10, 1335	Trip blank	Liquid
WSTCDV-10-25513/3037	09/01/10, 1335	Drilling fluids	Liquid
WSTCDV-10-25514/3037	09/01/10, 1335	Drilling fluids	Liquid
WSTCDV-10-25515/3037	09/01/10, 1335	Drilling fluids	Liquid
WSTCDV-10-25516/3039	09/07/10, 1400	Trip blank	Liquid
WSTCDV-10-25517/3039	09/07/10, 1400	Development water	Liquid
WSTCDV-10-25518/3039	09/07/10, 1400	Development water	Liquid
WSTCDV-10-25519/3039	09/07/10, 1400	Development water	Liquid
WST16-10-26545/3080	09/17/10, 1110	Well development water	Liquid
WST16-10-26546/3080	09/17/10, 1110	Well development water	Liquid
WST16-10-26547/3080	09/17/10, 1110	Well development water	Liquid
WST16-10-26548/3080	09/17/10, 1110	Trip blank	Liquid
WST16-11-1190/3177	10/29/10, 1500	Well development water	Liquid
WST16-11-1191/3177	10/29/10, 1500	Well development water	Liquid
WST16-11-1192/3177	10/29/10, 1500	Trip blank	Liquid
WST16-11-1193/3177	10/29/10, 1500	Trip blank	Liquid
WST16-11-1627/3211	11/03/10, 1435	Well development water	Liquid
WST16-11-1628/3211	11/03/10, 1435	Well development water	Liquid
WST16-11-1629/3211	11/03/10, 1435	Trip blank	Liquid
WST16-11-1630/3211	11/03/10, 1435	Trip blank	Liquid

Appendix A

Well CdV-16-4ip Borehole Lithologic Log

Borehole Identification (ID): CdV-16-4ip	**Technical Area (TA):** 16	**Page:** 1 of 16
Drilling Company: Layne Christensen Co.	**Start Date/Time:** 08/04/10 1224	**End Date/Time:** 08/12/10 1651
Drilling Method: Air Rotary	**Machine:** Schramm T130XD RIG T25	**Sampling Method:** Grab
Ground Elevation: 7463.76		**Total Depth:** 1153.7 ft bgs
Driller: E. Applegarth, R. Treptow, K. Keller	**Site Geologists:** T. Klepfer, M. Whitson, B. Larzelere, D. Staires, A. Feltman, S. Thomas	

Depth (ft bgs)	**Lithologic Description**	**Lithologic Symbol**	**Notes**
0–5	**UNIT 4 OF THE TSHIREGE MEMBER OF THE BANDELIER TUFF:** Tuff, white (7.5YR8/1) to pink (7.5YR7/4), partly welded to nonwelded, crystal- and lithic-rich tuff fragments (ash, sparse pumices, phenocrysts, and lithics), volcanic lithics, and quartz and sanidine phenocrysts in an ashy/sandy matrix. +10F: 70% lithic fragments, 27% tuff fragments, 3% quartz and sanidine crystals (inclusions in quartz noted). +35F: 40% quartz and sanidine crystals, 35% lithic fragments, 25% tuff fragments. Trace organics (woody debris) noted in WR sample. Minor orange-brown oxidation on some lithics and tuff fragments.	Qbt 4	
5–20	Tuff, white (7.5YR8/1) to pink (7.5YR7/3), partly welded to nonwelded, crystal- and lithic-rich tuff fragments (ash, sparse pumices, phenocrysts, and lithics), volcanic lithics, and quartz and sanidine phenocrysts in an ashy/sandy and silty matrix. Pumices show “sugary” texture and relict tube structures appear altered by devitrification and/or vapor-phase alteration. +10F: 70–75% tuff fragments, 20–28% lithic fragments, 2–5% quartz and sanidine crystals. +35F: 50–65% tuff fragments, 25–45% quartz and sanidine crystals, 5–10% lithic fragments. Inclusions in quartz crystals noted. Minor orange-brown oxidation on tuff fragments.	Qbt 4	
20–30	Tuff, white (7.5YR8/1) to pink (7.5YR7/3), partly welded to nonwelded, crystal- and lithic-rich tuff fragments (ash, sparse pumices, phenocrysts, and lithics), volcanic lithics, and quartz and sanidine phenocrysts in an ashy/sandy and silty matrix. Pumices show “sugary” texture and relict tube structures appear altered by devitrification and/or vapor-phase alteration. +10F: 55–60% lithic fragments, 20–30% tuff fragments, 10–25% quartz and sanidine crystals. +35F: 45–55% quartz and sanidine crystals, 30–45% lithic fragments, 10–15% tuff fragments. Inclusions in quartz crystals noted. Minor orange-brown oxidation on tuff fragments.	Qbt 4	

Borehole Identification (ID): CdV-16-4ip	**Technical Area (TA):** 16	**Page:** 2 of 16
Drilling Company: Layne Christensen Co.	**Start Date/Time:** 08/04/10 1224	**End Date/Time:** 08/12/10 1651
Drilling Method: Air Rotary	**Machine:** Schramm T130XD RIG T25	**Sampling Method:** Grab
Ground Elevation: 7463.76		**Total Depth:** 1153.7 ft bgs
Driller: E. Applegarth, R. Treptow, K. Keller	**Site Geologists:** T. Klepfer, M. Whitson, B. Larzelere, D. Staires, A. Feltman, S. Thomas	

Depth (ft bgs)	Lithologic Description	Lithologic Symbol	Notes
30–40	Tuff, white (7.5YR8/1) to light gray (7.5YR7/1), partly welded to nonwelded, crystal- and lithic-rich tuff fragments (ash and sparse pumice, phenocrysts, and lithics), volcanic lithics, and quartz and sanidine phenocrysts in an ashy/sandy and silty matrix. +10F: 60–70% lithic fragments, 15–30% tuff fragments, 10–15% quartz and sanidine crystals. +35F: 35–45% quartz and sanidine crystals, 25–45% volcanic lithic fragments, 20–30% tuff fragments. Bipyramidal quartz and quartz with inclusions noted. Minor orange-brown oxidation on some fragments.	Qbt 4	
40–50	Tuff, white (7.5YR8/1) to light gray (7.5YR7/1), partly welded to nonwelded, crystal- and lithic-rich tuff fragments (ash and sparse pumice, phenocrysts, and lithics), volcanic lithics, and abundant quartz and sanidine phenocrysts in an ashy/sandy and silty matrix. Some pumices show “sugary” texture and relict tube structures appear altered by devitrification and/or vapor-phase alteration. +10F: 50–65% tuff fragments, 27–45% volcanic lithics, 5–8% quartz and sanidine crystals. +35F: 45–60% tuff fragments, 10–35% lithic fragments, 20–30% quartz and sanidine crystals. Bipyramidal quartz and quartz with inclusions noted.	Qbt 4	
50–55	**UNIT 3t OF THE TSHIREGE MEMBER OF THE BANDELIER TUFF:** Tuff, white (7.5YR8/1) to light gray (7.5YR7/1), partly welded to nonwelded, crystal- and lithic-rich tuff fragments (ash and sparse pumice, phenocrysts, and lithics), volcanic lithics, and abundant quartz and sanidine phenocrysts in an ashy/sandy and silty matrix. Some pumices show “sugary” texture and relict tube structures appear altered by devitrification and/or vapor-phase alteration. +10F: 50–65% tuff fragments, 27–45% volcanic lithics, 5–8% quartz and sanidine crystals. +35F: 45–60% tuff fragments, 10–35% lithic fragments, 20–30% quartz and sanidine crystals. Bipyramidal quartz and quartz with inclusions noted.	Qbt 3t	Note: Contact between Qbt 4 and Qbt 3t at 50 ft bgs determined based on cuttings.

Borehole Identification (ID): CdV-16-4ip	**Technical Area (TA):** 16	**Page:** 3 of 16
Drilling Company: Layne Christensen Co.	**Start Date/Time:** 08/04/10 1224	**End Date/Time:** 08/12/10 1651
Drilling Method: Air Rotary	**Machine:** Schramm T130XD RIG T25	**Sampling Method:** Grab
Ground Elevation: 7463.76		**Total Depth:** 1153.7 ft bgs
Driller: E. Applegarth, R. Treptow, K. Keller	**Site Geologists:** T. Klepfer, M. Whitson, B. Larzelere, D. Staires, A. Feltman, S. Thomas	

Depth (ft bgs)	Lithologic Description	Lithologic Symbol	Notes
55–65	Tuff, reddish gray (2.5YR6/1) to gray (7.5YR6/1), partly welded to moderately welded, crystal- and lithic-rich devitrified tuff fragments (ash and sparse pumice, phenocrysts, and lithics), volcanic lithics, and abundant quartz and sanidine phenocrysts in an ashy/sandy matrix. Pumices show “sugary” texture and relict tube structures appear altered by devitrification and/or vapor-phase alteration. +10F: 90–98% tuff fragments, trace–8% volcanic lithics, 2–5% quartz and sanidine crystals. +35F: 55–65% tuff fragments, 20–25% quartz and sanidine crystals, 10–25% volcanic lithics. Bipyramidal quartz and quartz with inclusions noted. Minor orange to orange-brown oxidation on some fragments.	Qbt 3t	
65–95	Tuff, reddish gray (2.5YR6/1) to gray (7.5YR5/1), partly welded to densely welded, crystal- and lithic-rich devitrified tuff fragments (ash and gray to light gray pumice, phenocrysts, and lithics), volcanic lithics, and abundant quartz and sanidine phenocrysts in silty clay matrix. +10F: 80–90% tuff fragments (up to 2 cm), 3–18% volcanic lithics, 2–7% quartz and sanidine crystals. +35F: 40–50% tuff fragments, 50–55% quartz and sanidine crystals, trace–5% lithic fragments. Bipyramidal quartz and quartz with inclusions noted.	Qbt 3t	Abundant clay and silt (silty clay) in this interval. 75–80 ft bgs interval contains tuff fragments up to 2 cm in diameter.
95–100	Same as above. No clay and little silt in WR sample matrix. Predominantly sandy matrix (very fine to very coarse).	Qbt 3t	
100–112	Tuff, light reddish gray (2.5YR7/1) to dark gray (5YR5/1), partly welded/slightly indurated, crystal- and lithic-rich devitrified tuff fragments (ash and sparse pumice, phenocrysts, and lithics), volcanic lithics, and abundant quartz and sanidine phenocrysts in an ashy/sandy matrix. +10F: 90–95% tuff fragments, 2–5% quartz and sanidine crystals, trace–3% lithic fragments. +35F: 45–60% tuff fragments, 40–50% quartz and sanidine crystals, trace–5% lithic fragments. Bipyramidal quartz, quartz with inclusions, and glass shards noted. Abundant orange to orange-brown oxidation on tuff fragments.	Qbt 3t	

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Drilling Method: Air Rotary	Machine: Schramm T130XD RIG T25	Sampling Method: Grab
Ground Elevation: 7463.76		Total Depth: 1153.7 ft bgs
Driller: E. Applegarth, R. Treptow, K. Keller	Site Geologists: T. Klepfer, M. Whitson, B. Larzelere, D. Staires, A. Feltman, S. Thomas	

Depth (ft bgs)	Lithologic Description	Lithologic Symbol	Notes
112–125	**UNIT 3 OF THE TSHIREGE MEMBER OF THE BANDELIER TUFF:** Tuff, light reddish gray (2.5YR7/1) to dark gray (5YR5/1), partly welded to moderately welded, crystal- and lithic-rich devitrified tuff fragments (ash and sparse pumice, phenocrysts, and lithics), minor volcanic lithics, and abundant quartz and sanidine phenocrysts in an ashy/sandy matrix. +10F: 90–95% tuff fragments, 2–5% quartz and sanidine crystals, trace–3% lithic fragments. +35F: 45–60% tuff fragments, 40–50% quartz and sanidine crystals, trace–5% lithic fragments.	Qbt 3	Contact between Qbt 3t and Qbt 3 at approximately 112 ft bgs.
125–135	Tuff, reddish gray (2.5YR6/1) to gray (7.5YR5/1), partly welded to moderately welded, crystal- and lithic-rich devitrified tuff fragments (ash and gray to light gray pumice, phenocrysts, and lithics), volcanic lithics, and abundant quartz and sanidine phenocrysts in silty clay matrix. +10F: 85–96% tuff fragments, 2–10% volcanic lithics, 2–5% quartz and sanidine crystals. +35F: 40–50% tuff fragments, 50–55% quartz and sanidine crystals, trace–5% lithic fragments. Bipyramidal quartz and quartz with inclusions noted. Abundant orange-brown oxidation on tuff fragments.	Qbt 3	Abundant clay and silt (silty clay) in this interval.
135–140	Tuff, reddish gray (2.5YR6/1) to dark gray (7.5YR6/1) partly welded/slightly indurated to moderately welded, crystal- and lithic-rich devitrified tuff fragments (ash and pumice, phenocrysts, and lithics), volcanic lithics, and abundant quartz and sanidine phenocrysts in an ashy/sandy matrix. +10F: 58% tuff fragments, 40% quartz and sanidine crystals, 2% lithic fragments. +35F: 50% tuff fragments, 45% quartz and sanidine crystals, 5% lithic fragments. Bipyramidal quartz and quartz with inclusions noted.	Qbt 3	
140–190	Tuff, reddish gray (2.5YR5/1) to light gray (7.5YR7/1), minor partly welded to nonwelded, crystal- and lithic-rich devitrified tuff fragments (ash and sparse to no pumice, phenocryst, and lithics), volcanic lithics, and abundant quartz and sanidine phenocrysts. +10F: 40–45% tuff fragments, 50–60% quartz and sanidine crystals, 2–7% lithic fragments. +35F: 30–35% tuff fragments, 50–65% quartz and sanidine crystals, 3–7% lithic fragments. Bipyramidal quartz and quartz with inclusions noted. Abundant orange-brown oxidation on fragments.	Qbt 3	Abundant clay and silt (silty clay) in this interval. Noticeable decline in tuff fragments and increase in quartz and sanidine crystals.

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Drilling Company: Layne Christensen Co.	**Start Date/Time:** 08/04/10 1224	**End Date/Time:** 08/12/10 1651
Drilling Method: Air Rotary	**Machine:** Schramm T130XD RIG T25	**Sampling Method:** Grab
Ground Elevation: 7463.76		**Total Depth:** 1153.7 ft bgs
Driller: E. Applegarth, R. Treptow, K. Keller	**Site Geologists:** T. Klepfer, M. Whitson, B. Larzelere, D. Staires, A. Feltman, S. Thomas	

Depth (ft bgs)	**Lithologic Description**	**Lithologic Symbol**	**Notes**
140–190	Tuff, reddish gray (2.5YR5/1) to light gray (7.5YR7/1), minor partly welded to nonwelded, crystal- and lithic-rich devitrified tuff fragments (ash and sparse to no pumice, phenocryst, and lithics), volcanic lithics, and abundant quartz and sanidine phenocrysts. +10F: 40–45% tuff fragments, 50–60% quartz and sanidine crystals, 2–7% lithic fragments. +35F: 30–35% tuff fragments, 50–65% quartz and sanidine crystals, 3–7% lithic fragments. Bipyramidal quartz and quartz with inclusions noted. Abundant orange-brown oxidation on fragments.	Qbt 3	Abundant clay and silt (silty clay) in this interval. Noticeable decline in tuff fragments and increase in quartz and sanidine crystals.
180–190	**UNIT 2 OF THE TSHIREGE MEMBER OF THE BANDELIER TUFF:** Tuff, reddish gray (2.5YR5/1) to light gray (7.5YR7/1), minor partly welded to nonwelded, crystal- and lithic-rich devitrified tuff fragments (ash and sparse to no pumice, phenocryst, and lithics) and abundant quartz and sanidine phenocrysts. +10F:40–45% tuff fragments, 50–60% quartz and sanidine crystals, 2–7% lithic fragments. +35F: 30–35% tuff fragments, 50–65% quartz and sanidine crystals, 3–7% lithic fragments.	Qbt 2	Note: Contact between Qbt 3 and Qbt 2 at 180 ft bgs determined, in part, on minor increase on Los Alamos National Laboratory (LANL) natural gamma log and appearance of moderately to strongly welded tuff fragments indicative of Qbt 2. Significant increase in tuff fragments and decrease in quartz and sanidine crystals.
190–240	Tuff, reddish gray (2.5YR5/1) to gray (7.5YR5/1), moderately welded to densely welded/indurated, devitrified and vapor-phase altered, crystal-rich tuff fragments (ash and sparse pumice, phenocrysts, and trace to minor lithics), volcanic lithics, and quartz and sanidine phenocrysts in an ashy/sandy/silty matrix. Relict pumices show "sugary" texture, altered by devitrification and vapor-phase alteration. +10F: 80–90% tuff fragments, 5–10% quartz and sanidine crystals, trace–4% lithic fragments. +35F: 75–85% tuff fragments, 15–25% quartz and sanidine crystals, trace–3% lithic fragments. Abundant bipyramidal quartz and quartz with inclusions noted. Minor brown to dark orange-brown oxidation on most tuff fragments.	Qbt 2	

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Drilling Method: Air Rotary	**Machine:** Schramm T130XD RIG T25	**Sampling Method:** Grab
Ground Elevation: 7463.76		**Total Depth:** 1153.7 ft bgs
Driller: E. Applegarth, R. Treptow, K. Keller	**Site Geologists:** T. Klepfer, M. Whitson, B. Larzelere, D. Staires, A. Feltman, S. Thomas	

Depth (ft bgs)	**Lithologic Description**	**Lithologic Symbol**	**Notes**
240–245	Tuff, gray (7.5YR6/1) to dark brown (7.5YR3/2), moderately welded to densely welded/indurated, devitrified, and vapor-phase altered crystal-rich tuff fragments (ash and pumice, phenocrysts, and minor lithics), minor volcanic lithics and quartz and sanidine phenocrysts in an ashy/sandy/silty matrix. +10F: 60% tuff fragments, 37% quartz and sanidine crystals, 3% lithic fragments. +35F: 65% tuff fragments, 31% quartz and sanidine crystals, 4% lithic fragments. Bipyramidal quartz and quartz with inclusions noted.	Qbt 2	
245–280	Tuff, gray (7.5YR5/1) to dark gray (7.5YR4/1), moderately to densely-welded/indurated, devitrified and vapor-phase altered, crystal-rich tuff fragments (ash and pumice, phenocrysts, and minor lithics), minor volcanic lithics and quartz and sanidine phenocrysts in an ashy/sandy matrix. Evidence of flattened pumices in tuff fragments, show “sugary” texture. +10F: 90–98% tuff fragments, trace–8% quartz and sanidine crystals, trace–2% lithic fragments. +35F: 75–85% tuff fragments, 10–20% quartz and sanidine crystals, trace–5% lithic fragments. Bipyramidal quartz and quartz with inclusions noted. Abundant dark orange-brown oxidation on tuff fragments.	Qbt 2	
280–285	Tuff, reddish gray (5YR5/2) to gray (7.5YR5/1), moderately welded to densely welded/indurated, devitrified and vapor-phase altered crystal-rich tuff fragments (ash and pumice, phenocrysts, and lithics), volcanic lithics and quartz and sanidine phenocrysts in an ashy/sandy matrix. +10F: 92% tuff and pumice fragments, 5% lithic fragments, 3% quartz and sanidine crystals. +35F: 64% tuff fragments, 32% quartz and sanidine crystals, 4% lithic fragments. Bipyramidal quartz and inclusions in quartz noted. Dark orange-brown oxidation on tuff fragments.	Qbt 2	
290–315	Tuff, dark reddish gray (2.5YR4/1) to gray (7.5YR5/1), partly welded to moderately welded, devitrified tuff fragments (ash and pumice, phenocrysts, and lithics), abundant volcanic lithics and quartz and sanidine crystals in an ashy/sandy matrix. +10F: 50–60% lithic fragments (up to 1.5 cm), 25–35% tuff fragments, 5–25% quartz and sanidine crystals. +35F: 70–80% quartz and sanidine crystals, 10–15% lithic fragments, 10–15% tuff fragments. Orange-brown oxidation on most tuff fragments.	Qbt 2	Noticeable decrease in percentage of tuff fragments with increase in lithic fragments and crystals.

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Drilling Method: Air Rotary	**Machine:** Schramm T130XD RIG T25	**Sampling Method:** Grab
Ground Elevation: 7463.76		**Total Depth:** 1153.7 ft bgs
Driller: E. Applegarth, R. Treptow, K. Keller	**Site Geologists:** T. Klepfer, M. Whitson, B. Larzelere, D. Staires, A. Feltman, S. Thomas	

Depth (ft bgs)	Lithologic Description	Lithologic Symbol	Notes
315–325	**UNIT 1v OF THE TSHIREGE MEMBER OF THE BANDELIER TUFF:** Tuff, pale red (2.5YR6/2) to gray (5YR6/1), sparse partly welded to nonwelded, devitrified, crystal-rich tuff fragments (ash and pumice, phenocrysts, and lithics), quartz and sanidine phenocrysts, and volcanic lithics in an ashy matrix. +10F: 70% lithic fragments, 25% quartz and sanidine crystals, 5% tuff fragments. +35F: 70% quartz and sanidine crystals, 22% lithic fragments, 8% tuff fragments. Bipyramidal quartz and inclusions in quartz noted.	Qbt 1v	Note: Contact between Qbt 2 and Qbt 1v at 315 ft bgs is based on cuttings and geophysical logs. Minor decreases shown on the LANL natural gamma log and the Schlumberger thorium log over a short interval (possibly washout) followed by increases in both logs.
325–330	Tuff, light gray (5YR7/1) to gray (5YR5/1), sparse partly welded to nonwelded, devitrified crystal-rich light orange-brown to light gray tuff fragments (ash and pumice, phenocrysts, and lithics), light gray porous/fibrous pumice fragments, abundant quartz and sanidine phenocrysts, and volcanic lithics in an ashy/sandy matrix. +10F: 86–92% lithic fragments, 8–12% tuff fragments, trace–2% quartz and sanidine crystals. +35F: 75–85% lithic fragments,10–15% quartz and sanidine crystals, 5–10% tuff fragments. Bipyramidal quartz and inclusions in quartz noted.	Qbt 1v	
330–340	**UNIT 1g OF THE TSHIREGE MEMBER OF THE BANDELIER TUFF:** Tuff, gray (5YR6/1) to light brown (7.5YR6/4), nonwelded to partly welded, light orange-brown to light gray tuff fragments (ash and pumice, phenocrysts, and lithics), light gray to white porous/fibrous, vitric pumice lapilli fragments, quartz and sanidine phenocrysts, and abundant volcanic lithics in light gray to pinkish white ashy/sandy matrix. Black mineral phase, possibly amphibole, noted in some pumice fragments. +10F: 75–82% lithic fragments, <0.5–1.0 cm, 15–20% tuff and pumice fragments, 3–5% quartz and sanidine crystals. +35F: 40–50% lithic fragments, 25–30% tuff and pumice fragments, 20–35% quartz and sanidine crystals. Bipyramidal quartz and inclusions in quartz noted.	Qbt 1g	Note: Contact between Qbt 1v and Qbt 1g at 330 ft bgs determined based on the first appearance of volcanic glass and light gray to white vitreous pumice lapilli in cuttings (at 330–335 ft bgs). Minor decreases shown on natural gamma and thorium logs. Note: Marked increase in lithic content in WR and +10F sample.

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Drilling Method: Air Rotary	**Machine:** Schramm T130XD RIG T25	**Sampling Method:** Grab
Ground Elevation: 7463.76		**Total Depth:** 1153.7 ft bgs
Driller: E. Applegarth, R. Treptow, K. Keller	**Site Geologists:** T. Klepfer, M. Whitson, B. Larzelere, D. Staires, A. Feltman, S. Thomas	

Depth (ft bgs)	Lithologic Description	Lithologic Symbol	Notes
340–345	**CERRO TOLEDO INTERVAL:** Volcaniclastic sediments, gray (5YR6/1) to light brown (7.5YR6/4), moderately to well sorted, poorly graded very fine to coarse sand, very fine to medium gravels, grains angular to subrounded (GP-SP). +10F: detrital constituents (up to 0.75 cm) composed of 73% volcanic lithic fragments, 25% reworked, fibrous pumice fragments, 2% quartz crystals (smoky quartz noted). +35F: 45% lithic fragments, 25% tuff and pumice fragments, 30% quartz and sanidine crystals.	Qct	Note: Contact between Qbt 1g and Qct at 340 ft bgs based on cuttings, appearance of volcaniclastic sediments, and shifts on natural gamma and thorium logs.
345–350	Volcaniclastic sediments, gray (10YR5/1) to very pale brown (10YR7/3), moderately to well sorted, poorly graded very fine to coarse sand, very fine to medium gravels, grains angular to subrounded (GP-SP). +10F: detrital constituents (up to 0.75 cm) composed of 65% white to light orange-brown reworked, fibrous pumice fragments, 35% volcanic lithic fragments, trace quartz crystals (smoky quartz noted). +35F: 35% reworked vitric, fibrous pumice fragments, 40% quartz and sanidine crystals, 35% volcanic lithic fragments. Light orange-brown oxidation.	Qct	
350–375	Volcaniclastic sediments, gray (10YR6/1) to pale brown (10YR6/3), moderately to poorly sorted, poorly graded with very fine to very coarse sand, granules, fine to coarse gravels, and silt, grains subangular to subrounded (GP-SP). +10F: detrital constituents (up to 2 cm) composed of 55–65% felsic-intermediate composition volcanic lithics, 35–43% white to light orange-brown reworked fibrous pumice fragments, trace–2% quartz crystals and obsidian (smoky quartz noted). +35F: 45–60% volcanic lithics, 35–45% vitric pumice fragments, 5–10% quartz and sanidine crystals. Abundant light orange-brown oxidation.	Qct	
375–380	Volcaniclastic sediments, very pale brown (10YR8/2) to light gray (10YR7/1), moderately sorted, poorly graded with very fine to very coarse sand, granules, fine gravels, minor silt, grains sub rounded (SP-GP). +10F: detrital constituents (up to 0.5 cm) composed of 70% white to light orange-brown fibrous pumice fragments, 28% felsic-intermediate composition volcanic lithics, trace–2% quartz crystals and obsidian (smoky quartz noted). +35F: 75% vitric pumice fragments, 20% volcanic lithics, 5% quartz and sanidine crystals. Light orange-brown oxidation.	Qct	

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Ground Elevation: 7463.76		**Total Depth:** 1153.7 ft bgs
Driller: E. Applegarth, R. Treptow, K. Keller	**Site Geologists:** T. Klepfer, M. Whitson, B. Larzelere, D. Staires, A. Feltman, S. Thomas	

Depth (ft bgs)	Lithologic Description	Lithologic Symbol	Notes
380–390	Volcaniclastic sediments, very pale brown (10YR7/3) to reddish gray (2.5YR5/1), moderately sorted, poorly graded with minor silt, very fine to very coarse sand, granules, fine to medium gravels, grains subangular to subrounded (SP-GP). +10F: detrital constituents (up to 0.5–1.0 cm) composed of 55–65% felsic-intermediate composition volcanic lithics, 35–45% white to light orange-brown reworked fibrous pumice fragments, trace–1% quartz crystals and obsidian. +35F: 50–60% volcanic lithics, 37–45% vitric pumice fragments, 3–5% quartz and sanidine crystals. Abundant light orange-brown oxidation.	Qct	
390–400	Volcaniclastic sediments, very pale brown (10YR8/2) to reddish gray (2.5YR6/1), moderately to well sorted, poorly graded with fine to very coarse sand, minor granules, fine to medium gravels, grains subangular to subrounded (SP-GP). +10F: detrital constituents (up to 0.5–1.3 cm) composed of 65–75% felsic-intermediate composition volcanic lithics, 25–35% white to light orange-brown fibrous pumice fragments, trace smoky quartz. +35F: 40–55% volcanic lithics, 37–55% vitric pumice fragments, 5–7% quartz and sanidine crystals.	Qct	
400–425	Volcaniclastic sediments, very pale brown (10YR8/2) to gray (5YR5/1), moderately to poorly sorted with silt, very fine to very coarse sand, granules, minor fine to medium gravels, grains subangular to subrounded (SW/SM-GW). +10F: detrital constituents (up to 0.75 cm) composed of 40–55% felsic-intermediate composition volcanic lithics, 45–60% white to light orange-brown tuff and fibrous pumice fragments, trace–1% quartz crystals. +35F: 35–45% tuff and pumice fragments, 40–50% volcanic lithics, 5–25% quartz and sanidine crystals.	Qct	
425–450	Volcaniclastic sediments, gray (7.5YR6/1) to reddish gray (2.5YR6/1), moderately to poorly sorted, with silt, very fine to very coarse sand, granules, fine to coarse gravels, grains subangular to subrounded (SW/SM-GW). +10F: detrital constituents (up to 1.5 cm) composed of 75–90% felsic to intermediate volcanic lithics, 10–25% white to light orange-brown tuff and fibrous, porous pumice fragments, trace–no crystals. +35F: 35–45% volcanic lithics, 45–55% quartz and sanidine crystals, 10–20% tuff and pumice fragments.	Qct	

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Drilling Method: Air Rotary	**Machine:** Schramm T130XD RIG T25	**Sampling Method:** Grab
Ground Elevation: 7463.76		**Total Depth:** 1153.7 ft bgs
Driller: E. Applegarth, R. Treptow, K. Keller	**Site Geologists:** T. Klepfer, M. Whitson, B. Larzelere, D. Staires, A. Feltman, S. Thomas	

Depth (ft bgs)	Lithologic Description	Lithologic Symbol	Notes
450–465	Same as above (425–450 ft bgs interval) with higher quartz and sanidine content in +35F sample, 75–85% quartz and sanidine crystals.	Qct	
465–555	Volcaniclastic sediments, gray (7.5YR6/1) to dark reddish gray (2.5YR4/1), moderately to poorly sorted, with silt, very fine to very coarse sand, granules, fine to medium gravels, grains subangular to subrounded (SW/SM-GW). +10F: detrital constituents (up to 0.5–1.0 cm) composed of 75–90% felsic to intermediate volcanic lithics, 8–25% reworked tuff and white to light orange-brown fibrous, porous pumice fragments, trace–2% quartz crystals. +35F: 25–45% volcanic lithics, 45–65% quartz and sanidine crystals, 10–15% tuff and pumice fragments.	Qct	
555–560	Volcaniclastic sediments, light gray (10YR7/2) to gray (5YR5/1), moderately to poorly sorted with silt very fine to very coarse sand, granules, fine to coarse gravels, grains subangular (SW/SM-GW). +10F: detrital constituents (up to 2.0 cm) composed of 80% volcanic lithics, 20% reworked tuff and white to light orange-brown fibrous, porous pumice fragments, trace quartz crystals. +35F: 40% volcanic lithics, 35% quartz and sanidine crystals, 25% tuff and pumice fragments.	Qct	
560–605	Volcaniclastic sediments, pale brown (10YR6/3) to reddish gray (2.5YR5/1), moderately to poorly sorted with very fine to very coarse sand, granules, fine to medium gravels, minor silt, sparse granules, grains subangular to subrounded (SW/SM-GW). +10F: detrital constituents (up to 2.0 cm) composed of 75–95% volcanic lithics, 2–25% reworked tuff and white to light gray and orange-brown fibrous, porous pumice fragments, trace–3% quartz and sanidine crystals. +35F: 45–60% quartz and sanidine crystals, 25–30% tuff and pumice fragments, 10–30% lithic fragments. Bipyramidal quartz and smoky quartz noted.	Qct	

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Drilling Method: Air Rotary	**Machine:** Schramm T130XD RIG T25	**Sampling Method:** Grab
Ground Elevation: 7463.76		**Total Depth:** 1153.7 ft bgs
Driller: E. Applegarth, R. Treptow, K. Keller	**Site Geologists:** T. Klepfer, M. Whitson, B. Larzelere, D. Staires, A. Feltman, S. Thomas	

Depth (ft bgs)	Lithologic Description	Lithologic Symbol	Notes
605–625	Volcaniclastic sediments, very pale brown (10YR7/3) to reddish gray (2.5YR5/1), moderately to well sorted with abundant silt, very fine to very coarse sand, granules, fine gravels, grains subangular to subrounded (SM-GM). +10F: detrital constituents (up to 0.5 cm) composed of 65–80% volcanic lithics, 18–35% reworked tuff and white to light orange-brown and light gray fibrous pumice fragments, trace–2% quartz and sanidine crystals. +35F: 55–60% quartz and sanidine crystals, 25–30% tuff and vitric pumice fragments, 10–20% volcanic lithics.	Qct	Note: Increase in silt content in this interval.
625–630	Volcaniclastic sediments, very pale brown (10YR7/3) to reddish gray (2.5YR5/1), moderately to poorly sorted with very coarse sand to coarse gravel size volcanic lithic fragments (on average 1.0–≥2.0 cm) and silt (GW-SW/SM), grains subrounded. +10F: 95% volcanic lithics, 5% reworked tuff and pumice fragments, trace crystals. +35F: 55–60% quartz and sanidine crystals, 25–30% tuff and vitric pumice fragments, 10–20% volcanic lithics.	Qct	Note: Increase in fragment size in this interval. Predominantly granule-gravel size.
630–635	**OTOWI MEMBER OF THE BANDELIER TUFF:** Tuff, very pale brown (10YR7/3) to light gray (10YR7/1), partly welded to nonwelded, white to light gray and light orange-brown, fibrous, vitric pumice fragments with well preserved tubular structure, varieties of aphanitic to porphyritic volcanic lithic fragments (on average 0.5–1.0 cm) and phenocrysts in a light orange-brown ashy/sandy matrix. +10F: 85% light gray to light orange-brown fibrous pumice fragments and tuff, 15% volcanic lithic fragments, trace quartz crystals. +35F: 70% pumice and tuff fragments, 22% volcanic lithic fragments, 8% quartz and sanidine crystals	Qbo	Note: Contact between Qct and Qbo at approximately 628 ft bgs determined from cuttings and an abrupt increase on LANL natural gamma log. Abundant pumice fragments are rounded to well rounded.

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Drilling Method: Air Rotary		**Machine:** Schramm T130XD RIG T25	**Sampling Method:** Grab
Ground Elevation: 7463.76			**Total Depth:** 1153.7 ft bgs
Driller: E. Applegarth, R. Treptow, K. Keller		**Site Geologists:** T. Klepfer, M. Whitson, B. Larzelere, D. Staires, A. Feltman, S. Thomas	

Depth (ft bgs)	**Lithologic Description**	**Lithologic Symbol**	**Notes**
635–685	Tuff, very pale brown (10YR7/3) to reddish gray (2.5YR5/1), partly welded to nonwelded, white to light gray and light orange-brown, fibrous, vitric pumice fragments, varieties of aphanitic to porphyritic volcanic lithic fragments (on average ≤0.5 mm–1.0 mm), some granules (up to 1.5–2.0 cm) and phenocrysts in a light orange-brown ashy/sandy matrix. +10F: 70–83% light gray to light orange-brown fibrous, porous vitric pumice fragments, 15–30% volcanic lithic fragments, trace–2% quartz crystals and obsidian fragments. +35F: 50–55% pumice fragments, 30–35% volcanic lithic fragments, 10–20% quartz and sanidine crystals. Minor oxidation of pumice and lithic fragments.	Qbo	
685–730	Tuff, very pale brown (10YR8/2) to gray (7.5YR6/1), partly welded to nonwelded, white to light gray and light orange-brown, fibrous, vitric pumice fragments, varieties of aphanitic to porphyritic volcanic lithic fragments (≥1.0 cm) and phenocrysts in a white to tan ashy/sandy matrix. Pumice fragments rounded to well rounded. +10F: 55–70% pumice fragments, 30–45% lithic fragments, trace–2% quartz and sanidine crystals. +35F: 55–65% pumice fragments, 20–25% quartz and sanidine crystals, 10–25% lithic fragments. Bipyramidal quartz and quartz with inclusions noted.	Qbo	
730–735	Tuff, white (10YR8/1) to light gray (10YR7/1), partly welded to nonwelded, white, fibrous, vitric pumice fragments, varieties of aphanitic to porphyritic volcanic lithic fragments and phenocrysts in a white ashy/sandy/silty matrix. Pumice fragments rounded to well rounded. +10F: 85% pumice fragments, 15% lithic fragments, trace quartz crystals. +35F: 70% pumice fragments, 20% lithic fragments, 10% quartz and sanidine crystals. Bipyramidal quartz and quartz with up to 0.5 inclusions noted.	Qbo	
735–755	Tuff, very pale brown (10YR7/3) to light gray (10YR6/1), partly welded to nonwelded, white to light orange-brown, fibrous, porous, vitric pumice fragments, varieties of aphanitic to porphyritic volcanic lithic fragments (up to 0.5 cm in +10F) and phenocrysts in a tan ashy/sandy matrix. +10F: 75–90% pumice fragments, 10–25% lithic fragments, trace quartz crystals. +35F: 55–60% pumice fragments, 25–30% lithic fragments, 10–20% quartz and sanidine crystals.	Qbo	Predominantly composed of subrounded to rounded tuff and pumice.

Borehole Identification (ID): CdV-16-4ip	**Technical Area (TA):** 16		**Page:** 13 of 16
Drilling Company: Layne Christensen Co.	**Start Date/Time:** 08/04/10 1224		**End Date/Time:** 08/12/10 1651
Drilling Method: Air Rotary	**Machine:** Schramm T130XD RIG T25		**Sampling Method:** Grab
Ground Elevation: 7463.76			**Total Depth:** 1153.7 ft bgs
Driller: E. Applegarth, R. Treptow, K. Keller	**Site Geologists:** T. Klepfer, M. Whitson, B. Larzelere, D. Staires, A. Feltman, S. Thomas		

Depth (ft bgs)	**Lithologic Description**	**Lithologic Symbol**	**Notes**
755–775	Tuff, white (10YR8/1) to light gray (10YR7/1), nonwelded, white, fibrous, porous, vitric pumice fragments and trace phenocrysts. +10F: 100% pumice fragments. +35F: 100% pumice fragments.	Qbo	Note: Marked increase in pumice fragments. This interval contains 100% pumice fragments.
775–792	Tuff, white (10YR8/1) to dark gray (10YR4/1), partly welded to nonwelded, white to light gray fibrous, porous, vitric pumice fragments, varieties of aphanitic to porphyritic volcanic lithic fragments and phenocrysts in an ashy/sandy matrix. +10F: 45–60% pumice fragments, 40–55% lithic fragments (up to 1.0 cm), trace quartz crystals. +35F: 55–65% pumice fragments, 20–25% lithic fragments, 10–25% quartz and sanidine crystals.	Qbo	
792–800	**GUAJE PUMICE BED OF THE OTOWI MEMBER OF THE BANDELIER TUFF:** Tuff, white (10YR8/1) to reddish gray (2.5YR5/1), white fibrous, vitric pumice fragments, varieties of aphanitic to porphyritic intermediate volcanic lithics including dacite (up to 1.0 cm), and phenocrysts. +10F: 65–80% lithic fragments, 20–45% pumice fragments. +35F: 60–75% pumice fragments, 15–25% volcanic lithics, 10–15% quartz and sanidine crystals. Bipyramidal quartz noted.	Qbog	Note: Contact between Qbo and Qbog at 792 ft bgs corresponds with minor decrease on the LANL natural gamma log and stratified deposits noted in video log.
800–815	**PUYE FORMATION:** Volcaniclastic sediments, very pale brown (10YR7/3) to reddish gray (2.5YR5/1), poorly sorted with very fine to very coarse sand, fine to coarse gravels, and silt (GW-SM), grains subangular to subrounded (up to ≥2.5 cm), abundant dacite clasts. +10F: 90–97% aphanitic to porphyritic felsic-intermediate composition volcanic lithics (predominantly dacitic), 3–10% tuff and pumice fragments. +35F: 85–90% volcanic lithics, 5–10% pumice fragments, 3–5% quartz and sanidine crystals. 810–815 ft: clast size increases to 1.5–≥4.0 cm.	Tpf	Note: Contact between Qbog and Tpf at 800 ft bgs corresponds with a significant decrease on the LANL natural gamma log and abundant gravels and boulders noted in video log.

Borehole Identification (ID): CdV-16-4ip	**Technical Area (TA):** 16	**Page:** 14 of 16
Drilling Company: Layne Christensen Co.	**Start Date/Time:** 08/04/10 1224	**End Date/Time:** 08/12/10 1651
Drilling Method: Air Rotary	**Machine:** Schramm T130XD RIG T25	**Sampling Method:** Grab
Ground Elevation: 7463.76		**Total Depth:** 1153.7 ft bgs
Driller: E. Applegarth, R. Treptow, K. Keller	**Site Geologists:** T. Klepfer, M. Whitson, B. Larzelere, D. Staires, A. Feltman, S. Thomas	

Depth (ft bgs)	Lithologic Description	Lithologic Symbol	Notes
815–835	Volcaniclastic sediments, reddish gray (2.5YR5/1) to gray (7.5YR5/1), poorly sorted with fine to very coarse sand and fine to very coarse gravels (GW-SW), grains subangular to subrounded (up to ≥3.0 cm). +10F: +10F: 97–100% aphanitic to porphyritic felsic-intermediate composition volcanic lithics (predominantly dacitic), 0–3% tuff and pumice fragments. +35F: 93–95% volcanic lithics, 5–7% pumice fragments, trace–1% quartz and sanidine crystals.	Tpf	Note: the cuttings descriptions reflect clast sizes that are circulated to the surface. Borehole video log indicates the Puye Formation is largely made up of boulders and cobbles in a sandy to silty matrix. The drilling process reduces the boulders and cobbles to gravel- and sand-size clasts.
835–855	Volcaniclastic sediments, reddish gray (2.5YR6/1) to gray (7.5YR5/1), poorly sorted with very fine to very coarse sand, fine to coarse gravels, and minor silt (GW-SM), grains subangular to rounded (up to ≥2.5 cm). +10F: 95–99% aphanitic to porphyritic felsic-intermediate composition volcanic lithics (predominantly dacitic), 1–5% pumice fragments, trace quartz and obsidian, trace siltstone. +35F: 90–96% volcanic lithics, 2–5% pumice fragments, trace–2% quartz and sanidine crystals.	Tpf	
855–860	Volcaniclastic sediments, reddish gray (2.5YR6/1) to gray (7.5YR5/1), moderately sorted with predominantly medium to very coarse sand and abundant very fine to very coarse gravels (granules) (GW-SW), grains subangular to rounded (up to ≥2.5 cm). +10F: 100% aphanitic to porphyritic felsic-intermediate composition volcanic lithics (predominantly dacitic). Clasts on average 1.0–2.0 cm. +35F: 95–98% volcanic lithics,1–5% tuff and pumice fragments, trace–1% quartz and sanidine crystal. Minor oxidation.	Tpf	

Borehole Identification (ID): CdV-16-4ip	**Technical Area (TA):** 16	**Page:** 15 of 16
Drilling Company: Layne Christensen Co.	**Start Date/Time:** 08/04/10 1224	**End Date/Time:** 08/12/10 1651
Drilling Method: Air Rotary	**Machine:** Schramm T130XD RIG T25	**Sampling Method:** Grab
Ground Elevation: 7463.76		**Total Depth:** 1153.7 ft bgs
Driller: E. Applegarth, R. Treptow, K. Keller	**Site Geologists:** T. Klepfer, M. Whitson, B. Larzelere, D. Staires, A. Feltman, S. Thomas	

Depth (ft bgs)	Lithologic Description	Lithologic Symbol	Notes
860–1000	Volcaniclastic sediments, reddish gray (2.5YR6/1) to gray (7.5YR5/1), moderately to poorly sorted with fine to very coarse sand, very fine to very coarse gravels, and trace to minor silt (GW-SW), grains subangular to rounded (up to ≥3.0 cm). +10F: 98–100% aphanitic to porphyritic felsic-intermediate composition volcanic lithics (predominantly dacitic). 0–2% tuff and pumice fragments. +35F: 95–99% volcanic lithics, 1–5% tuff and pumice fragments, trace–1% quartz and sanidine crystals, trace obsidian. Minor oxidation on some lithic fragments.	Tpf	Note: Formation micro-imager (FMI) log shows relatively more conductive layers (fines) from 991–995 ft bgs.
1000–1075	Volcaniclastic sediments, reddish gray (2.5YR6/1) to gray (7.5YR5/1), moderately to poorly sorted with very fine to very coarse sand, very fine to very coarse gravels, and trace silt (GW-SW), grains subangular to rounded (up to ≥3.0 cm). +10F: 100% aphanitic to porphyritic felsic-intermediate composition volcanic lithics (predominantly dacitic). +35% 100% volcanic lithics, trace quartz crystals, trace pumice fragments.	Tpf	Note: FMI log shows relatively more conductive layers (fines) from 1026–1027 ft bgs, 1069–1072 ft bgs.
1075–1080	Volcaniclastic sediments, reddish gray (2.5YR6/1) to gray (7.5YR5/1), moderately to poorly sorted with very fine to very coarse sand, very fine to medium gravels, and silt (SW-SM), grains subangular to rounded (up to 1.0 cm). +10F: 100% aphanitic to porphyritic felsic-intermediate composition volcanic lithics (predominantly dacitic). +35% 100% volcanic lithics, trace quartz crystals, trace pumice fragments.	Tpf	Note: FMI log shows relatively more conductive layers (fines) from 1077–1078 ft bgs.
1080–1100	Volcaniclastic sediments, reddish gray (2.5YR6/1) to gray (7.5YR5/1), moderately to poorly sorted with very fine to very coarse sand, very fine to coarse gravels, and trace silt (GW-SW), grains subangular to rounded (up to ≥2.0 cm). +10F: 100% aphanitic to porphyritic felsic-intermediate composition volcanic lithics (predominantly dacitic). +35% 100% volcanic lithics, trace quartz crystals, trace pumice fragments.	Tpf	Note: FMI log shows relatively more conductive layers (fines) from 1082–1083 ft bgs.

Borehole Identification (ID): CdV-16-4ip	**Technical Area (TA):** 16	**Page:** 16 of 16
Drilling Company: Layne Christensen Co.	**Start Date/Time:** 08/04/10 1224	**End Date/Time:** 08/12/10 1651
Drilling Method: Air Rotary	**Machine:** Schramm T130XD RIG T25	**Sampling Method:** Grab
Ground Elevation: 7463.76		**Total Depth:** 1153.7 ft bgs
Driller: E. Applegarth, R. Treptow, K. Keller	**Site Geologists:** T. Klepfer, M. Whitson, B. Larzelere, D. Staires, A. Feltman, S. Thomas	

Depth (ft bgs)	**Lithologic Description**	**Lithologic Symbol**	**Notes**
1100–1105	Volcaniclastic sediments, reddish gray (2.5YR6/1) to gray (7.5YR5/1), moderately to poorly sorted with very fine to very coarse sand, very fine to medium gravels, and silt (SW/SM-GW), grains subangular to rounded (up to 1.0 cm). +10F: 100% aphanitic to porphyritic felsic-intermediate composition volcanic lithics (predominantly dacitic). +35% 100% volcanic lithics, trace quartz crystals, trace pumice fragments.	Tpf	Note: Predominantly fines in this interval in video log. Note: FMI log shows relatively more conductive layers (fines) from 1100–1105 ft bgs.
1105–1153.7	Volcaniclastic sediments, reddish gray (2.5YR6/1) to gray (7.5YR5/1), moderately to poorly sorted with very fine to very coarse sand, very fine to coarse gravels, and trace silt (GW-SW), grains subangular to rounded (up to ≥2.0 cm). +10F: 100% aphanitic to porphyritic felsic-intermediate composition volcanic lithics (predominantly dacitic). +35% 100% volcanic lithics, trace quartz crystals, trace pumice fragments.	Tpf	Note: FMI log shows relatively more conductive layers (fines) from 1108–1110 ft bgs, 1115–1116 ft bgs, 1124.5–1125.5 ft bgs, and 1190–1131 ft bgs. Bottom of borehole at 1153.7 ft bgs.

Abbreviations

7.5YR 8/1 = Munsell soil color notation where hue, value, and chroma are expressed (e.g., hue = 10YR, value = 6, and chroma = 3)

% = percentage of a given material in sieved sample fraction

bgs = below ground surface

ft = feet

GM = silty gravels, poorly graded gravel-sand-silty mixtures.

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

GP = poorly graded gravels, gravel-sand mixtures, little or no fines

Qbt = Tshirege Member of the Bandelier Tuff

Qct = Cerro Toledo interval

Qbo = Otowi Member of the Bandelier Tuff

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

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

SM = silty sands, sand-silt mixtures

SP = poorly graded sands, gravelly sands, little or no fines

Tpf = Puye Formation

WR = whole rock (Note: WR designation is given first in each lithologic description)

+10F = plus no. 10 sieve sample fraction

+35F = plus no. 35 sieve sample fraction

Appendix B

Groundwater Analytical Results

B-1.0 SAMPLING AND ANALYSIS OF GROUNDWATER AT CDV-16-4ip

Ten water samples were collected during well development at well CdV-16-4ip at depths of 880 and 1135 ft below ground surface from the two screened intermediate perched zones. The samples were analyzed for total organic carbon (TOC) and the final sample from each screen was also analyzed for anions and metals. Laboratory analyses were conducted by Los Alamos National Laboratory's (LANL's or the Laboratory's) Earth and Environmental Sciences Group 14 (EES-14).

Nine additional samples were collected during continued pumping of the lower screened interval to assess hexahydro-1,3,5-trinitro-1,3,5-triazine (RDX) concentrations in that zone. The analyses were also conducted by EES-14.

B-1.1 EES-14 Analytical Techniques

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

Groundwater samples were analyzed using techniques specified by the U.S. Environmental Protection Agency (EPA) methods for water analyses. Ion chromatography (EPA Method 300, 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 using EPA Method 314.0, rev. 1. Total carbonate alkalinity (EPA Method 310.1) was measured using standard titration techniques.

Inductively coupled (argon) plasma optical emission spectroscopy (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 (EPA Method 200.8, rev. 5.4). For metals analyzed by both techniques, EES-14 reports the analytical result from the technique with the lower detection limit.

TOC analyses were performed according to EPA Method 415.1.

B-1.2 Field Parameters

B-1.2.1 Well Development

Water samples were drawn from the pump discharge line into sealed containers, and field parameters were measured using a YSI multimeter. Results of field parameters, consisting of pH, temperature, dissolved oxygen (DO), oxidation-reduction potential (ORP), specific conductance, and turbidity measured during development at well CdV-16-4ip are provided in Table B-1.2-1.

Upper Screen

During development of the upper screen, pH and temperature varied from 6.1 to 7.4 and from 11.7°C to 26.4°C, respectively. Concentrations of DO varied from 5.9 to 11.4 mg/L. Corrected oxidation-reduction potential (Eh) values determined from field ORP measurements varied from 251.1 to 497.1 mV (Table B-1.2-1). The temperature-dependent correction factors used to calculate Eh values from field ORP measurements, based on an Ag/AgCl, KCl-saturated filling solution contained in the ORP electrode, were

213.9, 208.9, and 203.9 mV at 10ºC, 15ºC, and 25ºC, respectively. Corrected Eh values and DO concentrations are consistent with the known relatively oxidizing conditions of the regional aquifer beneath the Pajarito Plateau. Specific conductance ranged from 121 to 144 μS/cm, and turbidity ranged from 32.7 to 8.0 nephelometric turbidity units (NTU) during development of the upper screen (Table B-1.2-1).

Lower Screen

During development of the lower screen, pH and temperature varied from 6.2 to 7.3 and from 9.6°C to 15.4°C, respectively. Concentrations of DO varied from 5.2 to 10.2 mg/L. Corrected Eh values determined from field ORP measurements ranged from 507.4 to 313.2 mV during development of the lower screen (Table B-1.2-1). The temperature-dependent correction factors used to calculate Eh values from field ORP measurements, based on an Ag/AgCl, KCl-saturated filling solution contained in the ORP electrode, were 213.9 and 208.9 mV at 10ºC and 15ºC, respectively. Specific conductance varied from 92 to 214 μS/cm, and turbidity values ranged between 486 and 0.1 NTU during development of the lower screen (Table B-1.2-1).

B-1.3 EES-14 Analytical Results

Analytical results for the two samples collected during well development for anions, cations, and metals analyses are provided in Table B-1.3-1. TOC results, all below 2 mgC/L, are presented in Table B-1.3-2. Perchlorate was not detected in either screened interval.

RDX results for samples collected during continued pumping of the lower screen are presented in Table B-1.3-3. Concentrations declined from 135 to 25 ppb over the course of the additional pumping.

B-1.4 Summary

Groundwater at well CdV-16-4ip is relatively oxidizing based on corrected positive Eh values and measurable concentrations of DO during well development and aquifer testing. TOC concentrations in both screens were less than 2 mgC/L; perchlorate was not detected; and RDX concentrations decreased in the lower screened interval over the course of additional pumping.

Table B-1.2-1
Purge Volumes and Water-Quality Parameters for CdV-16-4ip during Well Development

Date	Time	pH	Temp. (°C)	DO (mg/L)	ORP (mV)	Eh (mV)	Specific Conductivity (µS/cm)	Turbidity (NTU)	Pumping Rate (gpm)	Purge Volume between Samples (gal.)	Cumulative Purge Volume (gal.)
Well Development (Upper Screen)											
08/27/10	1105	Swabbing and bailing; no parameters measured.								na[a]	na
	1914	Swabbing and bailing; no parameters measured.								229.0	229.0
08/28/10	1304	Swabbing and bailing; no parameters measured.								na	229.0
	1316	7.1	26.4	7.3	131.1	330.0	121	nr[b]	nr	50.5	279.5
	1350	7.4	24.6	5.9	114.0	312.9	144	23.5	0.0	1.0	280.5
	1400	7.0	21.5	6.3	161.2	365.1	135	32.1	0.5	5.2	285.7
	1445	7.1	18.0	6.9	138.9	342.8	136	32.7	0.4	17.2	302.9
	1455	6.9	12.6	11.4	158.3	367.2	132	32.1	3.6	35.9	338.8
	1530	6.7	12.1	9.5	159.0	372.9	131	27.0	3.8	131.4	470.2
	1600	6.7	12.2	9.3	154.8	368.7	132	19.0	3.8	113.3	583.5
	1630	6.8	12.2	9.2	154.8	368.7	130	18.1	3.8	113.1	696.6
	1700	6.8	12.2	9.2	155.4	379.3	130	18.5	3.8	112.9	809.5
	1730	6.8	12.4	9.1	153.3	367.2	131	15.6	3.8	113.2	922.7
	1800	6.8	12.5	9.1	150.3	364.2	130	14.1	3.8	113.0	1035.7
	1830	6.8	12.3	9.1	150.7	364.6	130	14.3	3.8	113.0	1148.7
08/29/10	0730	No parameters measured, pump on								na	1148.7
	0745	6.1	13.2	7.1	241.2	450.1	123	17.4	nr	92.6	1241.3
	0800	6.5	11.7	7.2	196.4	410.3	123	17.1	7.4	110.3	1351.6
	0830	6.8	12.1	7.3	169.8	383.7	123	14.4	7.3	219.6	1571.2
	0900	6.9	12.2	7.4	163.8	377.7	122	10.8	7.3	219.3	1790.5
	0930	6.9	12.4	7.3	160.4	374.3	122	10.9	7.3	219.0	2009.5
	1000	6.9	12.5	7.4	157.8	371.7	122	10.0	7.3	219.0	2228.5
	1030	6.9	12.7	7.3	155.3	369.2	122	nr	7.3	218.6	2447.1
	1100	6.9	12.8	7.3	150.8	364.7	122	nr	7.3	218.4	2665.5
	1130	6.8	12.4	7.4	148.6	362.5	122	9.7	7.3	218.4	2883.9
	1200	6.8	12.5	7.4	152.2	366.1	122	nr[c]	7.3	217.9	3101.8
	1230	6.8	12.2	7.4	151.2	365.1	122	nr[c]	7.3	217.9	3319.7
	1300	6.9	12.7	7.9	135.8	344.7	122	15.5	7.3	217.6	3537.3
	1331	6.9	12.8	7.7	47.2	256.1	123	14.5	7.2	224.6	3761.9
	1400	7.1	12.6	7.6	65.1	274.0	122	13.1	7.2	209.6	3971.5
	1430	6.9	12.6	7.8	108.5	317.4	122	12.7	7.2	216.0	4187.5
	1500	6.9	12.6	7.6	115.6	324.5	122	16.8	7.2	216.2	4403.7
	1530	6.9	12.6	7.5	117.4	326.3	122	14.9	7.2	215.7	4619.4
	1600	6.9	12.4	7.9	119.1	333.0	122	15.9	7.2	215.5	4834.9
	1630	6.9	12.5	7.7	123.9	332.8	122	14.6	7.2	215.4	5050.3

Table B-1.2-1 (continued)

Date	Time	pH	Temp. (°C)	DO (mg/L)	ORP (mV)	Eh (mV)	Specific Conductivity (µS/cm)	Turbidity (NTU)	Pumping Rate (gpm)	Purge Volume between Samples (gal.)	Cumulative Purge Volume (gal.)
Well Development (Upper Screen) (cont.)											
08/29/10 (cont.)	1700	7.0	12.4	7.7	125.5	339.4	122	15.3	7.2	214.5	5264.8
	1730	6.9	12.0	7.7	128.2	342.1	122	13.0	7.1	213.7	5478.5
	1800	6.9	12.4	7.5	132.9	346.8	122	16.5	7.1	212.9	5691.4
	1830	6.9	12.1	7.6	135.3	349.2	122	11.2	7.1	212.7	5904.1
	1900	6.9	11.9	7.7	135.6	349.5	122	12.4	7.1	212.9	6117.0
08/30/10	0730	6.7	11.7	8.0	293.2	447.1	123	9.0	7.2	36.5	6153.5
	0800	6.7	11.9	7.1	176.4	390.3	125	24.7	4.9	165.1	6318.6
	0830	6.8	12.4	7.3	168.4	382.3	124	13.3	4.9	147.9	6466.5
	0900	6.8	12.6	7.2	165.6	374.5	124	14.1	5.0	148.3	6614.8
	0930	6.8	12.9	7.4	160.7	369.6	124	15.2	5.0	148.5	6763.3
	1000	6.8	12.8	7.3	158.2	367.1	124	16.4	4.9	148.2	6911.5
	1030	6.9	12.9	7.5	159.7	368.6	124	19.2	4.9	152.9	7064.4
	1100	6.9	12.5	7.7	149.9	358.8	124	15.7	4.9	142.6	7207.0
	1130	6.9	13.0	7.4	148.9	362.8	124	14.1	4.9	152.2	7359.2
	1200	6.9	13.0	7.4	148.2	357.1	124	14.7	4.9	142.4	7501.6
	1230	6.9	13.4	8.2	146.5	355.4	124	15.2	4.2	126.9	7628.5
	1300	7.0	13.4	7.9	145.5	354.4	124	23.3	2.9	86.1	7714.6
	1330	7.2	13.7	7.0	149.2	358.1	125	21.2	2.8	83.0	7797.6
	1400	6.9	13.9	7.8	153.2	362.1	125	14.4	3.0	88.4	7886.0
	1430	6.9	13.0	8.2	143.4	347.3	124	13.8	3.3	86.5	7972.5
	1500	6.8	12.7	8.4	144.4	353.3	123	13.2	4.8	143.0	8115.5
	1530	7.0	14.5	7.4	128.1	337.0	124	15.4	3.4	103.2	8218.7
	1600	6.9	13.9	7.7	146.5	355.4	124	15.1	2.6	79.2	8297.9
	1630	6.9	13.5	7.7	135.5	344.4	124	13.9	2.9	85.7	8383.6
	1700	6.9	13.8	7.4	134.7	343.6	124	12.0	2.8	85.0	8468.6
	1730	6.9	13.6	7.7	134.8	343.7	124	13.1	2.8	84.7	8553.3
	1800	6.9	13.4	7.6	140.5	349.4	124	12.9	2.8	83.3	8636.6
	1830	6.9	13.5	7.7	146.0	354.9	125	14.4	2.7	81.3	8717.9
08/31/10	0730	6.8	14.2	8.8	157.6	366.5	129	16.6	2.8	17.0	8734.9
	0800	6.8	13.0	8.7	155.5	364.4	128	19.8	2.8	83.8	8818.7
	0830	6.9	12.8	9.4	154.1	363.0	128	24.7	2.8	83.0	8901.7

Table B-1.2-1 (continued)

Date	Time	pH	Temp. (°C)	DO (mg/L)	ORP (mV)	Eh (mV)	Specific Conductivity (µS/cm)	Turbidity (NTU)	Pumping Rate (gpm)	Purge Volume between Samples (gal.)	Cumulative Purge Volume (gal.)
Well Development (Upper Screen) (cont.)											
08/31/10 (cont.)	0900	6.9	13.5	9.3	147.6	356.5	127	21.8	2.7	79.4	8981.1
	0930	6.9	13.9	8.8	147.3	355.2	129	22.9	2.6	77.3	9058.4
	1000	6.9	14.3	9.0	147.6	356.5	129	24.5	2.6	76.6	9135.0
	1030	6.9	14.7	8.5	148.7	357.6	129	26.6	2.4	72.6	9207.6
	1100	5.7	12.6	10.1	213.2	422.1	128	23.9	16.3	86.8	9294.4
	1130	6.9	12.0	10.8	150.8	364.7	127	13.2	15.8	474.4	9768.8
	1200	6.9	12.0	10.8	149.0	362.9	127	9.5	15.4	461.6	10230.4
	1230	6.9	11.9	11.0	144.2	358.1	127	8.0	15.3	458.6	10689.0
	1300	6.9	12.0	11.1	144.9	358.8	127	9.4	15.7	456.1	11145.1
Well Development (Lower Screen)											
09/09/10	1035	Swabbing and bailing; no parameters measured.								na	11145.1
	1759	Swabbing and bailing; no parameters measured.								84	11229.1
09/12/10	1445	Swabbing and bailing; no parameters measured.								na	11229.1
	1506	Swabbing and bailing; no parameters measured.								na	11229.1
	1522	6.2	15.4	8.8	200.5	409.4	127	67.1	2.8	45.5	11274.6
09/13/10	0717	nr	nr	nr	nr	nr	nr	nr	nr	na	11274.6
	0730	6.7	11.4	8.7	134.9	348.8	126	14.9	5.1	65.9	11340.5
	0800	6.8	10.8	9.6	133.0	346.9	125	11.2	4.6	138.7	11479.2
	0830	6.9	11.2	9.7	129.6	343.5	125	9.7	6.5	195.5	11674.7
	0900	6.9	11.2	9.9	131.1	345.0	125	9.9	6.0	181.2	11855.9
	0930	6.9	11.1	10.1	128.5	342.4	126	9.3	7.4	222.3	12078.2
	1000	6.8	11.2	10.2	129.1	343.0	126	8.6	7.3	218.9	12297.1
	1030	6.9	11.2	10.2	126.5	340.4	126	7.1	7.6	228.9	12526.0
	1100	6.9	11.1	10.1	129.2	343.1	126	6.7	7.9	236.0	12762.0
	1130	6.9	11.1	10.0	132.9	346.8	126	5.9	8.6	256.9	13018.9
	1200	6.9	11.2	10.1	135.6	349.5	125	6.1	8.5	255.8	13274.7
	1230	6.9	11.1	10.0	130.7	344.6	126	6.3	9.4	282.5	13557.2
	1300	6.8	11.2	9.9	134.7	348.6	126	5.3	9.6	287.5	13844.7
	1330	7.0	11.3	9.9	124.5	338.4	126	5.5	10.2	306.4	14151.1
	1400	7.0	11.2	9.9	123.8	337.7	127	4.3	10.3	308.4	14459.5
	1430	7.0	11.3	9.6	111.1	325.0	127	4.4	10.7	322.1	14781.6
	1500	6.9	11.3	9.6	126.0	339.9	127	5.9	10.9	327.1	15108.7
	1530	6.9	11.3	9.5	133.5	347.4	127	6.0	10.9	326.4	15435.1

Table B-1.2-1 (continued)

Date	Time	pH	Temp. (°C)	DO (mg/L)	ORP (mV)	Eh (mV)	Specific Conductivity (µS/cm)	Turbidity (NTU)	Pumping Rate (gpm)	Purge Volume between Samples (gal.)	Cumulative Purge Volume (gal.)
Well Development (Lower Screen) (continued)											
09/13/10 (cont.)	1600	6.9	11.4	9.5	138.4	352.3	127	6.5	11.6	349.1	15784.2
	1630	7.0	11.5	9.5	125.9	339.8	127	3.7	11.9	356.5	16140.7
	1700	6.9	11.3	9.5	130.7	344.6	127	5.0	11.8	355.1	16495.8
	1730	6.9	11.4	9.4	139.2	353.1	127	3.6	11.8	353.9	16849.7
	1800	6.9	11.3	9.4	128.9	342.8	127	4.3	12.2	364.8	17214.5
	1830	6.9	11.3	9.4	138.2	352.1	127	4.6	12.0	360.4	17574.9
09/14/10	1215	No parameters measured, pump on								na	17574.9
	1230	6.6	11.0	8.0	191.2	405.1	206	9.0	12.9	193.3	17768.2
	1300	6.9	11.4	7.9	156.6	370.5	208	4.5	12.3	369.9	18138.1
	1330	7.0	11.3	7.8	149.8	363.7	209	3.5	12.1	361.8	18499.9
	1400	7.0	11.5	7.8	150.6	364.5	209	4.2	12.1	362.5	18862.4
	1430	7.0	11.4	8.0	145.8	359.7	210	4.3	12.0	360.2	19222.6
	1500	7.0	11.6	7.7	150.6	364.5	208	6.5	12.4	347.1	19569.7
	1530	7.0	11.5	8.5	139.4	353.3	210	5.7	12.1	362.2	19931.9
	1600	7.0	11.5	8.1	131.5	345.4	210	5.0	12.0	359.3	20291.2
	1630	7.0	11.7	7.9	135.1	349.0	209	8.3	12.0	311.9	20603.1
	1700	7.0	11.7	8.0	124.6	338.5	211	10.1	11.1	332.6	20935.7
	1730	7.0	11.8	8.1	130.0	343.9	213	29.4	10.9	326.2	21261.9
	1800	6.4	11.5	8.0	138.6	352.5	214	25.4	10.0	301.1	21563.0
09/15/10	1100	No parameters measured, pump on								na	21563.0
	1130	7.0	11.6	7.6	154.6	368.5	125	17.5	8.2	246.2	21809.2
	1200	6.8	12.1	7.5	146.2	360.1	124	11.5	8.0	258.0	22067.2
	1230	7.0	12.1	7.5	145.5	359.4	125	14.9	8.3	249.4	22316.6
	1300	7.0	12.3	7.5	145.2	359.1	126	13.7	8.2	245.8	22562.4
	1330	7.0	12.3	7.5	145.1	359.0	127	7.3	8.1	243.0	22805.4
	1400	7.0	12.2	7.5	142.2	356.1	126	6.0	8.2	246.4	23051.8
	1430	7.0	12.3	7.5	143.1	357.0	127	6.2	8.0	240.1	23291.9
	1500	7.0	12.4	7.8	139.1	353.0	127	5.6	7.9	237.9	23529.8
	1530	7.0	12.3	8.0	128.8	342.7	127	7.5	8.0	240.1	23769.9
	1600	7.0	12.3	8.0	122.6	336.5	127	6.3	8.0	238.8	24008.7
	1630	7.0	12.3	7.9	117.2	331.1	127	6.9	7.9	235.7	24244.4
	1700	7.0	12.2	8.0	127.5	341.4	128	7.2	7.9	235.4	24479.8

Table B-1.2-1 (continued)

Date	Time	pH	Temp. (°C)	DO (mg/L)	ORP (mV)	Eh (mV)	Specific Conductivity (µS/cm)	Turbidity (NTU)	Pumping Rate (gpm)	Purge Volume between Samples (gal.)	Cumulative Purge Volume (gal.)
Well Development (Lower Screen) (continued)											
09/15/10 (cont.)	1730	7.0	12.1	8.0	129.4	343.3	127	6.5	8.0	239.1	24718.9
	1800	7.0	11.9	8.0	135.2	349.1	127	7.1	8.2	244.6	24963.5
09/16/10	0700	No parameters measured, pump on								na	24963.5
	0730	6.9	11.1	7.7	157.7	371.6	124	3.1	10.8	325.3	25288.8
	0800	6.9	11.3	7.6	160.6	374.5	125	2.9	10.7	320.9	25609.7
	0830	7.0	11.5	7.4	157.2	371.1	126	3.5	11.2	335.9	25945.6
	0900	7.0	11.7	7.5	154.7	368.6	126	3.9	10.8	323.3	26268.9
	0930	7.0	11.9	7.5	152.8	366.7	126	2.6	10.9	325.8	26594.7
	1000	7.0	11.9	7.4	154.0	367.9	126	4.2	10.9	327.6	26922.3
	1030	7.0	12.0	7.5	153.3	367.2	126	6.4	11.1	332.2	27254.5
	1100	7.0	12.0	7.6	152.2	366.1	126	7.8	11.0	330.2	27584.7
	1130	7.0	12.2	7.5	153.2	367.1	126	9.0	11.0	331.0	27915.7
	1200	7.0	12.2	7.7	151.5	365.4	126	6.7	11.1	332.1	28247.8
	1230	7.0	12.2	7.8	152.7	366.6	126	6.8	11.0	329.8	28577.6
	1300	7.0	12.1	7.9	151.3	365.2	126	7.4	11.0	329.9	28907.5
	1330	7.0	12.1	7.8	153.1	367.0	126	8.7	10.9	327.0	29234.5
	1400	7.0	11.9	7.7	152.5	366.4	126	7.7	10.8	323.9	29558.4
	1430	7.1	12.3	7.5	149.2	363.1	126	18.0	9.6	220.5	29778.9
	1500	7.0	12.5	7.6	150.4	364.3	125	9.4	9.4	281.3	30060.2
	1530	7.0	12.5	7.7	149.8	363.7	126	6.8	9.3	280.1	30340.3
	1600	7.0	12.4	7.7	150.4	364.3	127	6.7	9.5	284.1	30624.4
	1630	7.0	12.5	7.6	141.7	355.6	128	6.6	9.3	277.7	30902.1
	1700	7.0	12.1	7.7	137.5	351.4	128	5.4	9.5	284.1	31186.2
	1730	7.0	12.1	7.9	147.0	360.9	128	6.6	9.4	280.9	31467.1
	1800	7.0	11.8	7.8	143.2	357.1	128	6.1	9.4	281.7	31748.8
09/17/10	0715	No parameters measured, pump on								na	31748.8
	0730	7.0	11.1	7.8	178.4	392.3	122	5.1	7.0	104.4	31853.2
	0800	7.1	11.7	7.0	158.9	372.8	135	58.1	6.5	193.9	32047.1
	0830	7.1	12.1	6.1	154.5	368.4	132	33.9	5.2	156.5	32203.6
	1030	7.1	11.8	7.8	175.0	388.9	136	92.1	11.0	131.7	32335.3
	1100	6.9	11.7	8.6	165.5	379.4	118	7.8	10.3	308.2	32643.5
	1130	6.9	11.7	8.2	158.8	372.7	119	5.0	10.7	321.1	32964.6
	1200	6.9	11.8	8.2	156.3	370.2	121	5.0	10.6	317.5	33282.1

Table B-1.2-1 (continued)

Date	Time	pH	Temp. (°C)	DO (mg/L)	ORP (mV)	Eh (mV)	Specific Conductivity (µS/cm)	Turbidity (NTU)	Pumping Rate (gpm)	Purge Volume between Samples (gal.)	Cumulative Purge Volume (gal.)
Well Development (Lower Screen) (continued)											
09/17/10 (cont.)	1230	7.0	11.9	8.3	147.3	361.2	121	6.3	10.8	323.5	33605.6
	1300	7.0	11.7	8.4	146.2	360.1	122	4.2	10.6	317.6	33923.2
	1330	7.0	11.6	8.5	148.1	362.0	122	4.7	10.5	316.0	34239.2
	1400	7.0	11.6	8.5	153.3	367.2	121	4.5	10.4	312.2	34551.4
	1430	7.0	12.0	8.5	165.3	379.2	122	5.3	10.4	311.5	34862.9
	1500	7.0	12.0	8.5	143.1	357.0	122	5.8	10.4	311.5	35174.4
	1530	7.0	12.0	8.5	129.8	343.7	122	4.8	10.5	313.5	35487.9
	1600	7.1	11.9	8.6	133.4	347.3	121	3.7	10.4	310.7	35798.6
	1630	7.0	11.9	8.6	145.8	359.7	122	5.8	10.4	311.4	36110.0
	1700	7.1	11.8	8.7	131.9	345.8	121	5.1	10.4	313.3	36423.3
	1730	7.1	11.6	8.7	134.0	347.9	121	5.7	10.4	313.0	36736.3
	1800	7.0	11.6	8.6	141.9	355.8	122	5.0	9.7	291.3	37027.6
09/18/10	0715	No parameters measured, pump on								na	37027.6
	0730	6.7	10.6	8.3	200.2	414.1	123	122.0	9.5	142.0	37169.6
	0800	6.9	11.6	7.0	177.7	391.6	129	12.9	9.1	271.4	37441.0
	0830	7.0	11.9	6.6	171.0	384.9	127	15.7	9.0	268.7	37709.7
	0900	7.0	12.0	8.4	171.0	384.9	128	36.9	8.8	238.4	37948.1
	0911	nr	nr	nr	nr	nr	nr	nr	8.6	94.5	38042.6
Continued Pumping (Lower Screen)											
10/21/10	0745	No parameters measured, pump on								na	38042.6
	0800	7.2	9.6	6.6	105.4	319.3	103	30.9	9.1	166.9	38209.5
	0830	7.1	11.0	5.7	99.4	313.3	101	16.2	9.1	271.4	38480.9
	0900	6.9	11.0	5.2	99.3	313.2	102	477.0	9.0	270.9	38751.8
	0930	7.1	11.1	5.2	100.9	314.8	104	486.0	8.9	265.5	39017.3
	1000	7.1	11.2	7.2	107.6	321.5	103	38.6	6.3	190.2	39207.5
	1030	7.0	11.4	7.1	117.4	331.3	102	16.5	5.5	164.9	39372.4
	1105	6.9	11.4	7.1	114.5	328.4	102	6.8	2.3	81.6	39454.0
	1130	6.9	10.9	7.8	118.6	332.5	99	10.6	5.6	127.7	39581.7
	1200	6.7	11.9	6.6	107.6	321.5	102	10.3	4.7	156.3	39738.0
	1230	6.9	11.8	6.6	103.8	317.7	102	2.6	4.6	138.3	39876.3
	1300	7.0	11.7	6.6	102.5	316.4	101	1.3	4.6	138.3	40014.6
	1330	6.9	11.6	6.6	113.3	327.2	101	1.3	4.6	137.7	40152.3

Table B-1.2-1 (continued)

Date	Time	pH	Temp. (°C)	DO (mg/L)	ORP (mV)	Eh (mV)	Specific Conductivity (µS/cm)	Turbidity (NTU)	Pumping Rate (gpm)	Purge Volume between Samples (gal.)	Cumulative Purge Volume (gal.)
Continued Pumping (Lower Screen) (cont.)											
10/21/10	1400	6.9	11.4	6.6	109.5	323.4	101	1.2	4.6	137.4	40289.7
	1430	7.0	11.8	6.5	111.7	325.6	101	1.2	4.6	137.2	40426.9
	1500	7.1	11.9	6.5	110.0	323.9	101	1.1	4.6	136.9	40563.8
	1530	7.0	11.4	6.5	113.1	327.0	101	1.0	4.6	136.9	40700.7
	1600	7.1	11.5	6.5	118.9	332.8	101	0.6	4.6	136.6	40837.3
	1630	7.1	11.4	6.5	117.7	331.6	101	0.8	4.6	136.6	40973.9
	1700	7.1	11.4	6.5	119.3	333.2	101	0.6	4.6	136.8	41110.7
	1730	7.1	11.3	6.5	121.6	335.5	101	0.5	4.6	136.4	41247.1
	1800	7.0	11.3	6.5	124.1	338.0	101	0.5	4.5	135.5	41382.6
	1815	nr	nr	nr	nr	nr	nr	nr	4.5	67.6	41450.2
10/22/10	0730	No parameters measured, pump on								na	41450.2
	0800	7.2	10.1	7.5	151.1	365.0	97	10.0	4.7	139.4	41589.6
	0830	7.2	10.9	7.0	136.7	350.6	97	2.7	4.8	143.1	41732.7
	0900	7.1	11.0	6.9	131.2	345.1	97	1.5	4.8	143.2	41875.9
	0930	7.1	11.2	6.8	133.9	347.8	97	1.6	4.8	143.6	42019.5
	1000	7.1	11.3	6.8	128.0	341.9	98	1.2	4.8	143.2	42162.7
	1030	7.1	11.3	6.8	128.2	342.1	97	1.2	4.8	142.9	42305.6
	1100	7.0	11.2	6.8	126.1	340.0	98	1.0	4.8	142.9	42448.5
	1130	6.9	11.3	6.9	129.4	343.3	98	1.2	5.2	156.7	42605.2
	1200	7.0	11.6	6.8	134.9	348.8	98	1.7	5.4	160.9	42766.1
	1230	7.0	11.4	7.0	122.1	336.0	99	19.3	5.9	177.1	42943.2
	1300	7.0	11.5	6.7	131.6	345.5	99	5.4	5.9	177.6	43120.8
	1330	7.1	11.4	6.6	114.3	328.2	99	3.6	5.9	176.3	43297.1
	1400	7.1	11.4	6.6	123.9	337.8	99	3.5	5.8	175.2	43472.3
	1430	7.0	11.7	6.5	133.3	347.2	99	3.0	5.8	174.0	43646.3
	1500	7.0	11.5	6.5	116.1	330.0	99	3.6	5.8	172.5	43818.8
	1530	7.1	11.4	6.4	119.3	333.2	99	6.6	5.7	170.2	43989
	1600	7.1	11.5	6.7	127.3	341.2	99	5.9	5.6	166.5	44155.5
	1630	7.1	11.3	6.8	125.3	339.2	99	3.2	5.1	152.9	44308.4
	1700	7.1	11.2	6.6	127.6	341.5	99	1.4	5.1	151.8	44460.2
	1730	7.1	11.2	6.6	130.3	344.2	99	1.0	5.1	152.6	44612.8
	1800	7.1	11.1	6.7	135.2	349.1	99	0.7	5.1	153.0	44765.8
	1830	7.0	11.1	6.7	132.3	346.2	99	0.8	5.1	152.9	44918.7

Table B-1.2-1 (continued)

Date	Time	pH	Temp. (°C)	DO (mg/L)	ORP (mV)	Eh (mV)	Specific Conductivity (µS/cm)	Turbidity (NTU)	Pumping Rate (gpm)	Purge Volume between Samples (gal.)	Cumulative Purge Volume (gal.)
Continued Pumping (Lower Screen) (cont.)											
10/23/10	0730	No parameters measured, pump on								na	44918.7
	0800	6.9	10.2	6.7	150.6	364.5	94	16.4	5.3	157.8	44918.7
	0830	7.0	10.9	6.0	138.4	352.3	95	4.2	5.4	161.6	45076.5
	0900	6.5	11.1	6.0	134.9	348.8	95	1.9	5.4	161.3	45238.1
	0930	6.8	11.1	6.1	132.3	346.2	95	1.1	5.4	161.0	45399.4
	1000	7.1	11.3	6.2	133.5	347.4	95	1.0	5.3	160.3	45560.4
	1030	7.1	11.3	6.1	130.7	344.6	95	0.8	5.3	159.7	45720.7
	1100	7.1	11.4	6.1	129.5	343.4	95	0.8	5.4	160.4	45880.4
	1130	7.1	11.6	6.1	126.7	340.6	95	0.8	5.3	160.0	46040.8
	1200	7.1	11.6	6.2	129.6	343.5	96	0.8	5.3	159.4	46200.8
	1230	6.5	11.6	6.1	131.3	345.2	96	0.7	5.3	159.4	46360.2
	1300	7.1	11.6	6.2	129.5	343.4	96	0.6	5.3	158.8	46519.0
	1330	7.1	11.4	6.2	120.6	344.5	96	0.8	5.3	158.7	46677.7
	1400	7.1	11.7	6.2	124.1	338.0	96	0.9	5.3	158.3	46836.0
	1430	6.9	11.6	6.1	126.5	340.4	96	0.9	5.3	158.3	46994.3
	1500	7.0	11.3	6.2	123.5	337.4	96	0.7	5.3	157.9	47152.2
	1530	7.0	11.4	6.3	124.5	338.4	96	0.8	5.3	157.8	47310.0
	1600	7.1	11.5	6.2	126.1	340.0	97	0.8	5.3	157.8	47467.8
	1630	7.1	11.6	6.2	131.7	345.6	97	1.0	5.3	157.5	47625.3
	1700	7.1	11.3	6.3	121.8	335.7	96	0.7	5.2	157.1	47782.4
	1730	7.0	11.2	6.2	126.8	340.7	97	0.7	5.2	157.0	47939.4
	1800	7.1	11.1	6.2	129.8	343.7	96	0.8	5.2	156.8	48096.2
	1830	7.1	11.1	6.2	132.0	345.9	96	0.6	5.2	155.7	48251.9
10/24/10	0730	No parameters measured, pump on								na	48251.9
	0800	6.9	10.2	6.3	155.0	368.9	92	9.2	5.6	159.6	48411.5
	0830	7.0	10.9	6.1	149.7	363.6	92	3.0	5.3	159.7	48571.2
	0900	7.0	11.2	6.1	142.7	356.6	92	1.0	5.3	159.4	48730.6
	0930	7.1	11.3	6.1	132.3	346.2	92	0.7	5.3	159.0	48889.6
	1000	7.1	11.4	6.0	131.5	345.4	92	0.6	5.3	158.9	49048.5
	1030	7.0	11.6	6.0	131.2	345.1	92	0.4	5.3	158.5	49207.0
	1100	7.0	11.4	5.9	118.8	332.7	93	0.4	5.2	156.9	49363.9
	1130	7.0	11.7	5.9	118.3	332.2	93	0.6	5.3	157.5	49521.4

Table B-1.2-1 (continued)

Date	Time	pH	Temp. (°C)	DO (mg/L)	ORP (mV)	Eh (mV)	Specific Conductivity (µS/cm)	Turbidity (NTU)	Pumping Rate (gpm)	Purge Volume between Samples (gal.)	Cumulative Purge Volume (gal.)
Continued Pumping (Lower Screen) (cont.)											
10/24/10 (cont.)	1200	7.0	11.3	5.9	101.2	315.1	93	0.6	5.3	157.4	49678.8
	1230	7.0	11.4	5.9	111.3	325.2	93	0.6	5.2	157.0	49835.8
	1300	7.0	11.6	5.9	117.4	331.3	93	0.6	5.2	156.9	49992.7
	1330	7.0	11.7	5.8	119.4	333.3	93	0.5	5.2	156.4	50149.1
	1400	7.1	11.9	5.7	107.5	321.4	93	0.7	5.2	156.9	50306.0
	1430	7.0	11.8	5.8	106.7	320.6	93	0.7	5.2	156.9	50462.9
	1500	7.1	11.7	5.8	107.7	321.6	94	0.7	5.2	156.7	50619.6
	1530	7.1	11.5	5.9	107.8	321.7	94	0.6	5.2	156.2	50775.8
	1600	7.1	11.4	5.9	114.2	328.1	94	0.5	5.2	156.2	50932.0
	1630	7.1	11.4	5.9	118.7	332.6	94	0.5	5.2	156.9	51088.9
	1700	7.0	11.3	5.9	122.0	335.9	94	0.6	5.2	156.7	51245.6
	1730	7.1	11.3	5.9	123.4	337.3	94	0.5	5.2	156.3	51401.9
	1800	7.0	11.2	6.0	125.7	339.6	94	0.5	5.2	156.0	51557.9
	1830	7.1	11.2	6.0	126.9	340.8	94	0.6	5.2	155.2	51713.1
10/25/10	1630	No parameters measured, pump on								na	51713.1
	1700	6.5	10.0	6.3	170.8	384.7	95	9.5	5.8	162.8	51875.9
	1730	6.9	10.5	6.0	146.0	359.9	95	3.3	5.4	161.6	52037.5
	1800	6.9	10.7	5.8	143.4	357.3	95	1.2	5.4	160.9	52198.4
	1830	7.0	10.7	5.8	141.6	355.5	95	0.7	5.3	159.9	52358.3
	1900	7.0	10.8	6.0	144.8	358.7	95	1.4	5.3	160.1	52518.4
	1930	7.0	10.8	6.0	143.3	357.2	95	1.2	5.3	160.0	52678.4
	2000	7.1	10.8	5.9	133.9	347.8	96	0.9	5.3	159.0	52837.4
	2030	7.1	10.7	5.9	137.5	351.4	96	0.8	5.3	158.4	52995.8
	2100	7.1	10.8	5.8	138.2	352.1	96	0.5	5.3	158.3	53154.1
	2130	7.1	10.8	5.7	139.2	353.1	96	0.6	5.3	158.1	53312.2
	2200	7.1	11.0	5.8	137.2	351.1	96	0.5	5.1	154.0	53466.2
	2230	7.1	11.0	5.9	139.0	352.9	96	0.5	4.9	146.9	53613.1
	2300	7.1	10.9	5.8	141.8	355.7	96	0.6	4.8	143.9	53757.0
	2330	7.1	10.9	5.8	140.8	354.7	96	0.7	4.7	142.3	53899.3
	0000	7.1	10.9	5.8	141.1	355.0	96	0.8	5.1	152.9	54052.2
10/26/10	0030	7.1	11.0	5.7	140.2	354.1	96	0.7	5.2	155.5	54207.7
	0100	7.1	10.9	5.7	141.2	355.1	96	0.7	5.2	155.4	54363.1
	0130	7.1	10.9	5.6	141.4	355.3	96	0.7	5.2	155.3	54518.4

Table B-1.2-1 (continued)

Date	Time	pH	Temp. (°C)	DO (mg/L)	ORP (mV)	Eh (mV)	Specific Conductivity (µS/cm)	Turbidity (NTU)	Pumping Rate (gpm)	Purge Volume between Samples (gal.)	Cumulative Purge Volume (gal.)
Continued Pumping (Lower Screen) (cont.)											
10/26/10 (cont.)	0200	7.1	10.9	5.6	141.5	355.4	96	0.6	5.2	154.8	54673.2
	0230	7.1	10.9	5.7	142.2	356.1	96	0.7	5.2	154.6	54827.8
	0300	7.1	10.9	5.6	142.6	356.5	96	0.8	5.2	154.5	54982.3
	0330	7.1	10.9	5.6	144.0	357.9	96	0.7	5.2	154.6	55136.9
	0400	7.1	10.9	5.7	144.0	357.9	96	0.8	5.2	154.7	55291.6
	0430	7.1	10.8	5.7	144.6	358.5	97	0.7	5.2	154.6	55446.2
	0500	7.1	10.8	5.7	144.5	358.4	97	0.7	5.2	154.5	55600.7
	0530	7.1	10.8	5.8	145.3	359.2	97	0.7	5.1	154.2	55754.9
	0600	7.1	10.8	5.8	145.8	359.7	97	0.7	5.1	154.3	55909.2
	0630	nr	nr	nr	nr	nr	nr	nr	5.1	154.2	56063.4
10/30/10	0730	No parameters measured, pump on								na	56063.4
	0800	6.9	10.7	7.7	115.2	329.1	112	860.0	5.2	155.6	56219.0
	0830	7.3	10.3	6.1	119.3	333.2	107	84.6	5.2	154.4	56373.4
	0900	7.3	11.1	6.4	124.8	338.7	105	13.3	5.2	155.5	56528.9
	0930	7.1	11.3	6.2	130.2	344.1	104	8.7	5.2	155.5	56684.4
	1000	7.1	11.4	6.1	129.4	343.3	104	7.3	5.2	155.2	56839.6
	1030	7.1	11.6	6.1	125.9	339.8	104	6.9	5.1	154.3	56993.9
	1100	7.1	11.6	6.0	128.3	342.2	104	6.1	5.1	154.1	57148.0
	1130	7.2	11.7	5.9	124.6	338.5	104	6.7	5.1	153.3	57301.3
	1200	7.1	11.9	5.8	126.4	340.3	104	7.0	5.2	155.4	57456.7
	1230	7.0	11.9	5.7	124.6	338.5	103	4.7	5.2	156.7	57613.4
	1300	7.1	12.0	5.7	125.1	339.0	103	4.1	5.2	156.5	57769.9
	1330	6.7	12.1	5.7	121.7	335.6	103	3.4	5.2	156.4	57926.3
	1400	7.1	12.1	5.6	120.1	334.0	103	4.2	5.2	157.1	58083.4
	1430	7.1	12.0	5.7	117.9	331.8	103	4.1	5.3	157.6	58241.0
	1500	7.2	12.0	5.6	117.1	331.0	103	3.7	5.3	157.9	58398.9
	1530	7.1	11.9	5.6	117.9	331.8	103	3.7	5.3	157.5	58556.4
	1600	7.2	11.7	5.6	117.1	331.0	103	3.6	5.2	157.0	58713.4
	1630	6.9	11.8	5.6	119.8	333.7	103	4.3	5.2	156.8	58870.2
	1700	7.2	11.5	5.6	115.4	329.3	103	4.0	5.2	156.7	59026.9
	1730	7.2	11.4	5.6	119.2	333.1	103	3.7	5.2	156.6	59183.5
	1800	7.2	11.3	5.6	125.5	339.4	103	1.2	5.2	156.1	59339.6
	1830	nr	nr	nr	nr	nr	nr	nr	5.2	156.0	59495.6

Table B-1.2-1 (continued)

Date	Time	pH	Temp. (°C)	DO (mg/L)	ORP (mV)	Eh (mV)	Specific Conductivity (µS/cm)	Turbidity (NTU)	Pumping Rate (gpm)	Purge Volume between Samples (gal.)	Cumulative Purge Volume (gal.)
Continued Pumping (Lower Screen) (cont.)											
10/31/10	0730	No parameters measured, pump on								na	59495.6
	0800	6.8	9.9	6.3	165.0	378.9	99	4.4	4.9	145.4	59641.0
	0830	7.0	10.9	6.1	151.5	365.4	99	3.6	4.8	144.0	59785.0
	0900	7.0	11.1	6.0	146.3	360.2	99	1.7	4.8	143.9	59928.9
	0930	7.0	11.3	6.0	144.3	358.2	99	1.3	4.8	143.2	60072.1
	1000	6.9	11.5	5.9	142.3	356.2	99	1.0	4.8	143.2	60215.3
	1030	7.0	11.6	5.9	140.0	353.9	99	0.7	4.8	143.1	60358.4
	1100	7.1	11.7	5.9	136.7	350.6	99	0.8	4.8	142.7	60501.1
	1130	7.1	11.7	5.9	134.1	348.0	100	0.8	4.8	142.5	60643.6
	1200	7.0	11.8	5.9	135.4	349.3	100	0.7	4.7	142.1	60785.7
	1230	7.0	11.8	5.9	135.4	349.3	100	1.0	4.8	142.5	60928.2
	1300	7.1	11.8	5.9	127.9	341.8	100	0.7	4.7	142.3	61070.5
	1330	7.1	11.8	5.9	134.1	348.0	100	0.4	4.7	142.3	61212.8
	1400	7.1	11.8	5.9	133.1	347.0	100	0.4	4.7	141.8	61354.6
	1430	7.1	11.9	5.9	127.4	341.3	100	0.5	4.7	142.3	61496.9
	1500	7.1	11.9	5.9	128.6	342.5	100	0.3	4.8	142.5	61639.4
	1530	7.1	11.9	5.8	127.6	341.5	100	0.4	4.7	142.2	61781.6
	1600	7.1	11.8	5.8	121.9	335.8	100	0.2	4.7	142.2	61923.8
	1630	7.1	11.8	5.8	120.5	334.4	100	0.5	4.7	142.3	62066.1
	1700	7.1	11.5	5.8	120.4	334.3	100	0.2	4.7	142.3	62208.4
	1730	7.1	11.3	5.9	123.9	337.8	100	0.5	4.7	142.3	62350.7
	1800	7.1	11.2	5.8	129.4	343.3	100	0.1	4.7	142.3	62493.0
	1830	nr	nr	nr	nr	nr	nr	nr	4.7	141.7	62634.7
11/01/10	0730	No parameters measured, pump on								na	62634.7
	0800	6.7	9.8	6.3	174.6	388.5	100	2.0	4.9	147.0	62781.7
	0830	7.0	11.0	6.0	154.2	368.1	99	1.2	4.8	144.0	62925.7
	0900	7.0	11.2	6.0	146.9	360.8	100	0.9	4.8	144.1	63069.8
	0930	7.1	11.4	5.9	141.2	355.1	100	0.6	4.8	144.4	63214.2
	1000	7.1	11.4	5.9	137.7	351.6	100	0.4	4.8	143.8	63358.0
	1030	7.1	11.5	5.9	133.2	347.1	100	0.4	4.8	144.0	63502.0
	1100	7.1	11.5	5.8	138.8	352.7	100	0.5	4.8	144.0	63646.0
	1130	7.1	11.5	5.8	135.5	349.4	100	0.5	4.8	144.3	63790.3
	1200	7.1	11.6	5.8	134.7	348.6	100	0.5	4.8	144.0	63934.3

Table B-1.2-1 (continued)

Date	Time	pH	Temp. (°C)	DO (mg/L)	ORP (mV)	Eh (mV)	Specific Conductivity (µS/cm)	Turbidity (NTU)	Pumping Rate (gpm)	Purge Volume between Samples (gal.)	Cumulative Purge Volume (gal.)
Continued Pumping (Lower Screen) (cont.)											
11/01/10 (cont.)	1230	7.1	11.6	5.8	132.3	346.2	101	0.3	4.8	143.7	64078.0
	1300	7.1	11.7	5.8	130.7	344.6	101	0.3	4.8	143.4	64221.4
	1330	7.2	11.7	5.8	126.6	340.5	101	0.4	4.8	143.3	64364.7
	1400	7.2	11.7	5.8	128.6	342.5	101	0.5	4.8	142.8	64507.5
	1430	7.2	11.7	5.8	130.6	344.5	101	0.4	4.8	143.4	64650.9
	1500	7.2	11.8	5.8	127.7	341.6	101	0.2	4.8	143.7	64794.6
	1530	7.2	11.6	5.8	124.0	337.9	101	0.1	4.8	143.4	64938.0
	1600	7.2	11.8	5.7	131.8	345.7	100	0.3	4.8	143.5	65081.5
	1630	7.2	11.7	5.7	130.2	344.1	100	0.3	4.8	143.2	65224.7
	1700	7.2	11.4	5.8	124.5	338.4	101	0.4	4.8	143.3	65368.0
	1730	7.2	11.2	5.8	127.8	341.7	101	0.1	4.8	143.4	65511.4
	1800	7.2	11.2	5.8	132.0	345.9	101	0.1	4.8	143.3	65654.7
	1830	nr	nr	nr	nr	nr	nr	nr	4.8	144.5	65799.2
11/02/10	1130	No parameters measured, pump on								na	65799.2
	1200	7.1	10.4	6.3	141.9	355.8	99	1.6	4.8	143.0	65942.2
	1230	7.1	11.5	6.2	138.1	352.0	100	1.1	4.9	146.0	66088.2
	1300	7.2	11.6	6.2	128.1	342.0	99	0.7	4.9	146.3	66234.5
	1330	7.2	11.7	6.2	125.6	339.5	100	0.3	4.9	146.6	66381.1
	1400	7.2	11.8	6.1	127.4	341.3	100	0.4	4.9	147.1	66528.2
	1430	7.2	11.8	6.1	122.3	336.2	100	0.1	4.9	146.9	66675.1
	1500	7.2	11.8	6.0	120.2	334.1	100	0.3	4.9	146.7	66821.8
	1530	7.2	11.8	6.0	119.6	333.5	100	0.4	4.9	145.9	66967.7
	1600	7.2	11.7	6.0	119.6	333.5	100	0.5	4.8	145.1	67112.8
	1630	7.2	11.6	6.0	116.9	330.8	100	0.6	4.8	145.1	67257.9
	1700	7.2	11.4	6.0	110.8	324.7	100	0.3	4.8	145.0	67402.9
	1730	6.7[d]	12.3[d]	5.9[d]	293.5[d]	507.4[d]	104[d]	0.9[d]	4.8	144.7	67547.6
	1801	6.1[d]	12.2[d]	5.7[d]	183.0[d]	396.9[d]	104[d]	0.8[d]	4.7	144.0	67691.6
	1818	nr	nr	nr	nr	nr	nr	nr	4.8	82.1	67773.7

[a] na = Not applicable.

[b] nr = Not recorded.

[c] YSI meter being calibrated.

[d] Parameters measured using TerraneaPMC equipment.

Table B-1.3-1
EES-14 Analytical Results

Sample ID	Ag Rslt (ppm)	Stdev[a] (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	Br(-) (U)	Ca Rslt (ppm)	Stdev (Ca)	Cd Rslt (ppm)	Stdev (Cd)	Cl(-) (ppm)	ClO4(-) (ppm)	ClO4(-) (U)	Co Rslt (ppm)	Stdev (Co)	Alk-CO3 Rslt (ppm)	ALK-CO3 (U)	Cr Rslt (ppm)	Stdev (Cr)	Cs Rslt (ppm)	Stdev (Cs)	Cu Rslt (ppm)	Stdev (Cu)
GW4ip-10-24995	0.001	U[b]	0.003	0.00	0.0006	0.0001	0.124	0.0002	0.408	0.003	0.001	U	0.09	U	11	9.E-02	0.001	U	6	0.005	U	0.001	U	1	U	0.003	0.000	0.001	U	0.001	U
GW4ip-10-26056	0.001	U	0.008	0.000	0.0006	0.0000	0.176	0.0002	0.585	0.004	0.001	U	0.08	U	10	1.E-02	0.001	U	7	0.005	U	0.001	U	0.08	U	0.001	0.000	0.001	U	0.001	U

Table B-1.3-1 (continued)

Sample ID	F(-) ppm	Fe Rslt (ppm)	Stdev (Fe)	Alk-CO3+HCO3 Rslt (ppm)	Hg Rslt (ppm)	Stdev (Hg)	K Rslt (ppm)	Stdev (K)	Li Rslt (ppm)	Stdev (Li)	Mg Rslt (ppm)	Stdev (Mg)	Mn Rslt (ppm)	Stdev (Mn)	Mo Rslt (ppm)	Stdev (Mo)	Na Rslt (ppm)	Stdev (Na)	Ni Rslt (ppm)	Stdev (Ni)	NO2 Rslt (ppm)	NO2-N Rslt	NO3 Rslt (ppm)	NO3-N Rslt	C2O4 Rslt (ppm)	C2O4 (U)	Pb Rslt (ppm)	Stdev (Pb)	Lab pH
GW4ip-10-24995	0.19	0.01	U	66	0.00005	U	1.166	4.E-03	0.007	1.433E-04	3.626	2.E-03	0.008	3.234E-04	0.001	U	13.43	5.E-03	0.002	2.707E-04	0.01	0.003	6	1.33	0.01	U	0.0002	U	7.10
GW4ip-10-26056	0.22	0.01	U	68	0.00005	U	1.049	4.E-03	0.008	3.242E-04	3.202	1.E-03	0.013	1.258E-04	0.001	U	15.83	4.E-02	0.002	5.900E-06	0.03	0.009	5	na[c]	0.01	U	0.0002	U	7.04

Table B-1.3-1 (continued)

Sample ID	PO4(-3) Rslt (ppm)	Rb Rslt (ppm)	Stdev (Rb)	Sb Rslt (ppm)	Stdev (Sb)	Se Rslt (ppm)	Stdev (Se)	Si Rslt (ppm)	Stdev (Si)	SiO2 Rslt (ppm)	Stdev (SiO2)	Sn Rslt (ppm)	Stdev (Sn)	SO4(-2) Rslt (ppm)	Sr Rslt (ppm)	Stdev (Sr)	Th Rslt (ppm)	Stdev (Th)	Ti Rslt (ppm)	Stdev (Ti)	Tl Rslt (ppm)	Stdev (Tl)	U Rslt (ppm)	Stdev (U)	V Rslt (ppm)	Stdev (V)	Zn Rslt (ppm)	Stdev (Zn)	Cations	Anions	Balance
GW4ip-10-24995	0.05	0.001	U	0.001	U	0.001	U	26	8.E-02	55	2.E-01	0.001	U	6	0.066	0.004	0.001	U	0.002	U	0.001	U	0.0005	0.0001	0.003	1.382E-04	0.107	0.001	1.5	1.5	-0.02
GW4ip-10-26056	0.06	0.001	U	0.001	U	0.001	U	30	2.E-01	64	5.E-01	0.001	U	8	0.059	0.000	0.001	U	0.002	U	0.001	U	0.0003	0.0000	0.003	2.620E-05	0.107	2.858E-04	1.5	1.6	-0.02

[a] Stdev = Standard deviation for detected analytes; U entered if not detected.
[b] U = Constituent not detected.
[c] na = Consituent not analyzed.

Table B-1.3-2
TOC Concentrations

Sample ID	Screened Interval	TOC (ppm)
GW4ip-10-24993	Upper	0.72
GW4ip-10-24994	Upper	0.72
GW4ip-10-24995	Upper	0.58
GW4ip-10-26049	Lower	1.16
GW4ip-10-26050	Lower	0.68
GW4ip-10-26051	Lower	0.78
GW4ip-10-26542	Lower	0.52
GW4ip-10-26543	Lower	0.55
GW4ip-10-26544	Lower	0.66
GW4ip-10-26056	Lower	0.58
GW4ip-11-1415	Lower	0.57
GW16-11-1943	Lower	0.51

Table B-1.3-3
RDX Concentrations in the Lower Screened Interval

Sample ID	Date Collected	RDX* (ppb)
GW4ip-11-1112	10/21/2010	135
GW4ip-11-1113	10/22/2010	125
GW4ip-11-1115	10/24/2010	85
GW4ip-11-1415	10/26/2010	57
GW16-11-1532	10/30/2010	179
GW16-11-1533	10/30/2010	34
GW16-11-1534	10/31/2010	36
GW16-11-1535	11/1/2010	36
GW16-11-1943	11/2/2010	25

*EES-14 analyses.

Appendix C

CdV-16-4ip Proposed Final Well Design and
New Mexico Environmental Department Approval

Note: The information in this final well design package was developed at the completion of borehole drilling. The formation depths and water levels presented herein were based on preliminary information and may differ slightly from the postinstallation lithologic interpretations and data and details presented in the well completion report.

CdV-16-4ip Well Objectives

Perched intermediate pumping well CdV-16-4ip is being installed as part of a hydrologic testing program to evaluate properties of the deep perched groundwater zone at Consolidated Unit 16-021(c)-99 (260 Outfall), located in Technical Area 16 in the southwest corner of Los Alamos National Laboratory. The tests will provide field-scale measurements of aquifer parameters for the deep-vadose-zone system that is expected to include zones with variable water content under capillary and full-saturation conditions. The well will be used to assess the potential for pumping and treatment of contaminants in the deep vadose zone groundwater associated with the 260 Outfall. Details of the hydrologic testing program are presented in “Hydrologic Testing Work Plan for Consolidated Unit 16-021(c)-99”.

CdV-16-4ip is designed to be the pumping well in the hydrologic testing program. It is located east of the main cluster of observation wells that include multiple well screens at R-25 and single well screens at R-25b, R-25c (screen currently dry), and CdV-16-1(i) (Figure 1). This location was selected to optimize the spatial distribution of potential pumping drawdowns at the observation wells. The distances of the observation wells from the pumping well range between 372 and 483 ft (Figure 2).

The work plan for well CdV-16-4ip tentatively identified a two-screen well design anticipating that the upper screen would be placed near the top of saturation in the Otowi Member of the Bandelier Tuff and the deeper screen in the underlying Puye Formation. Because Schlumberger geophysical logs indicate the Otowi Member is not saturated, we propose that CdV-16-4ip be completed with two well screens in the Puye Formation.

The well design described below is focused on optimizing the aquifer tests that support the CME for the 260 Outfall. Recommendations for final disposition for the purpose of long-term water-quality monitoring will be provided to NMED in separate correspondence following completion of the aquifer tests and interpretation of the data.

CDV-16-4ip Recommended Well Design

It is recommended that CdV-16-4ip be completed as a two-screen well with an upper 60-ft stainless-steel, 20-slot, wire-wrapped well screen near the top of saturation in the Puye Formation (screen 1) and a 30-ft stainless-steel, 20-slot, wire-wrapped well screen near the bottom of the borehole in the Puye Formation (screen 2). The primary filter pack will consist of 10/20 sand extending 5 ft above and 5 ft below both well screen openings. A 3-ft secondary filter pack consisting of 20/40 sand will be placed above the primary filter pack of both well screens. A packer will be installed to prevent cross flow between the two well screens prior to the hydrologic testing program. The proposed well design is shown in Figure 3.

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

CDV-16-4ip Well Design Considerations

At total depth (TD), the CdV-16-4ip borehole was cased from 0–625 ft and open hole from 625–1153.7 ft. Preliminary lithological logs indicate that the geologic contacts are, in descending stratigraphic order: ash-flow tuffs of the Tshirege and Otowi Members of the Bandelier Tuff with intercalated sedimentary deposits of the Cerro Toledo interval (0–800 ft) and boulders, cobbles, gravels, sands, and silts of the Puye Formation (800–1153.7 ft TD). Characterization activities included the collection of cuttings at 5 ft intervals, a borehole video log below 625 ft, Schlumberger and LANL geophysical logs, and water-level recovery tests at several intervals (see below) during drilling.

Borehole Video Observations:

A borehole video log was run after the borehole was drilled to the TD of 1153.7 ft. At a depth of 794 ft, in the Guaje Pumice Bed, a small amount of water was observed entering the borehole in the stratified pumice deposits but flow on the borehole wall did not appear to increase with depth through the pumice deposits. A 4.5-ft-thick massive silt bed (possible soil) occurs at the top of the Puye Formation between depths of 800–804.5 ft. Because of its fine-grained nature, this zone may act as a confining bed for the hydrostratigraphic units below and above this zone. There is significantly greater water flow entering the borehole within the top of the Puye Formation below the silt bed, which might be an indication for local confinement of the saturated zone. At a depth of 811 ft, there is strong water flow issuing from cobble and gravel beds at several points in the borehole. Water flow increases with depth, and below 825 ft depth cascading water completely obscures the view of the video log until standing water is reached. The water level at the time the video log was collected was 922 ft depth. From 922 ft to total depth, water in the borehole is remarkably clear and the video log provides excellent documentation of the coarse clastic deposits making up the Puye Formation.

Geophysical Logs:

Schlumberger geophysical logs were collected through a cased borehole from 0–625 ft and in an open borehole from 625–1151 ft. The logs included combinable magnetic resonance (CMR), array induction, APS porosity, spectral gamma, caliper, and formation microimager (FMI). Geophysical logging with LANL gamma and induction tools matches and supports the Schlumberger results.

Combined with information from the video log, the geophysical data indicate that the Puye Formation is a coarse fanglomerate made up of boulder and cobble deposits that are stacked in beds 1 to 5 ft thick. Log interpretations provided by Schlumberger indicate that Puye deposits have CMR and APS porosities of 20–30% and that the unit is fully saturated throughout the drilled interval. CMR logs indicate the highest effective porosities occur in the depth interval from 915 ft (the water level at the time of logging) to about 1000 ft (the zones of highest effective porosity are expected also to be highly permeable). High effective porosities probably also occur above 915 ft, especially where the borehole video indicates strong flow near the top of the Puye Formation. However, porosity logs, which are based on water content, are biased low for this interval by drainage of water to the borehole.

To further evaluate saturation above standing water in the borehole, Schlumberger computed water-filled porosity using Archie's equation with the deepest reading (90 in) resistivity log calibrated to the APS log. The water content based on resistivity porosity stays between 20-40% (except higher in fine-grained beds, as would be expected) through the entire section below 812 ft, which is within the total porosity range typical of the Puye and thus suggests total saturation. Also, both the resistivity porosity and deepest reading APS porosity indicate that water content in the Guaje Pumice Bed is 25% or less and water contents decrease up section to less than 10% above 758 ft. The total porosity of the Guaje Pumice Bed is typically 50-60% and porosity in the overlying tuffs is about 40%. Therefore it is likely these units are not saturated, and they probably retained a significant amount of introduced water that is slowly released when the borehole was drilled through them.

The Puye Formation contains thin sand and silt beds that are intercalated within the coarser deposits. Silt beds may act as confining beds for compartmentalizing the saturated zone. The most prominent zones containing such silt beds were identified by induction and FMI logs, and they occur 990–994 ft, 1069–1083 ft, 1100–1111 ft, and 1125–1131 ft depth intervals. The silt beds within these intervals are commonly intercalated with coarser fanglomerate deposits, and individual silt beds are typically 1 to 3 ft thick.

Water-level recovery tests:

Water-level recovery tests were performed during open-hole drilling at depths of 734, 794, 834, 934, 1034, and1153.7 ft (TD). In each case, drilling was paused, water was airlifted from the bottom of the borehole for 15-30 minutes, and recharge of the borehole was monitored. These tests were conducted to determine if water was present, to measure stable water levels, and to measure recovery rates. Plots of stable water levels in CdV-16-4ip as a function of borehole depth are shown in Figure 4. For reference, Figure 4 also shows water levels as function of screen depths for nearby wells R-25, R-25b, and CdV-16-2i(r) and a borehole water level measurement for R-25c at the Guaje/Puye contact.

At borehole depths of 734 and 794 ft in the Otowi Member at CdV-16-4ip, municipal water introduced during drilling was airlifted from the borehole and subsequent water-level measurements indicated there was no recharge of the borehole, suggesting the strata at these depths were unsaturated. Introduction of municipal water to aid drilling was largely stopped in the Puye Formation because groundwater production from the perched zone was sufficient to aid circulation of cuttings. At 834 and 934 ft depth in the Puye Formation, water levels stabilized within an hour at depths of 772 and 776 ft, respectively. These water levels are within the lower Otowi Member and are higher than expected based on borehole video and geophysical logs and on the dry recovery test performed at 794 ft. A preliminary interpretation of these higher-than-expected water levels is that perched water in the Puye Formation is pressurized (locally confined) beneath the silt bed from 800 to 804.5 ft, and that the observed water levels occurred only when the confining bed was penetrated by the open borehole. When the borehole was advanced to 1034 ft depth, the stable water level was 802 ft bgs, This water level occurs within the silt bed at the top of the Puye Formation, and again suggests locally confined conditions. During the final recovery test at 1153.7 ft (TD), water levels initially recovered from 892 to 867 ft bgs before steadily declining. The current (as of 8/17/2010) composite water level in the open borehole is 932 ft bgs and it continues to decline.

Based on the water-level data, there appear to be two distinct hydrologic zones in the vadose zone penetrated at the CdV-16-4ip location. The upper zone is a well-connected confined system with a upper confining bed at the top of the Puye Formation and a lower confining bed between depths of 934 and 1034 ft. The location of the lower confining bed is inferred in part on the water level decline that occurred when the 934 and 1034 ft interval was drilled (Figure 4). Water levels in nearby wells R-25 (screens 1 and 2) and R-25b were impacted during drilling at CDV-16-4ip, demonstrating hydraulic connection between CDV-16-4ip and R-25/R-25b in the upper zone. Water levels in screen 2 at R-25 measurably declined during drilling of the 934 and 1034 ft interval at CdV-16-4ip, suggesting a pressure response to penetration of a confining bed. Induction and FMI logs indicate that silt beds in the 990 to 994 ft interval at CdV-16-4ip likely form the lower confining bed for the upper hydrologic zone. The lower hydrologic zone is characterized by significantly lower water levels (~100 ft lower) and it appears to be poorly connected to upper vadose-zone groundwater.

Proposed Well Screen Intervals:

Screen 1, at 820 ft to 880 ft depth, targets the upper hydrologic zone in the Puye Formation. CdV-16-4ip is primarily designed to be a pumping well for the hydrologic testing program to assess the potential for pumping and treatment of contaminated deep-perched groundwater associated with the 260 Outfall. Groundwater monitoring data at well R-25 indicate that high-explosive contaminant concentrations are highest near the top of the perched groundwater system and that concentrations decrease with depth. Thus the planned testing would provide hydrologic information to assess remediation alternatives for the most contaminated part of the perched groundwater system. A 60-ft well screen is recommended for screen 1 to maximize the stress placed on the hydrologic system during pumping, increasing the likelihood that drawdown can be measured in the observation wells. The elevation of screen 1 overlaps the elevation of R-25 screen 2, and it could eventually replace the groundwater monitoring function of the upper screens in that well.

Screen 2, at 1105 to 1145 ft depth, targets the same depth as screen 4 at well R-25. Because of uncertainties associated with the water table map for the area, it is uncertain whether regional groundwater occurs in screen 4 or screen 5 at R-25. During testing, water levels in screens 4 and 5 at well R-25 will be monitored to determine if the two zones show a similar response to pumping of the lower well screen at CdV-16-4ip. Additionally, water levels in the upper well screen at CdV-16-4ip will be monitored during pumping of the lower well screen to assess whether a vertical hydraulic connection exists between the upper and lower part of the thick saturated interval at this location.

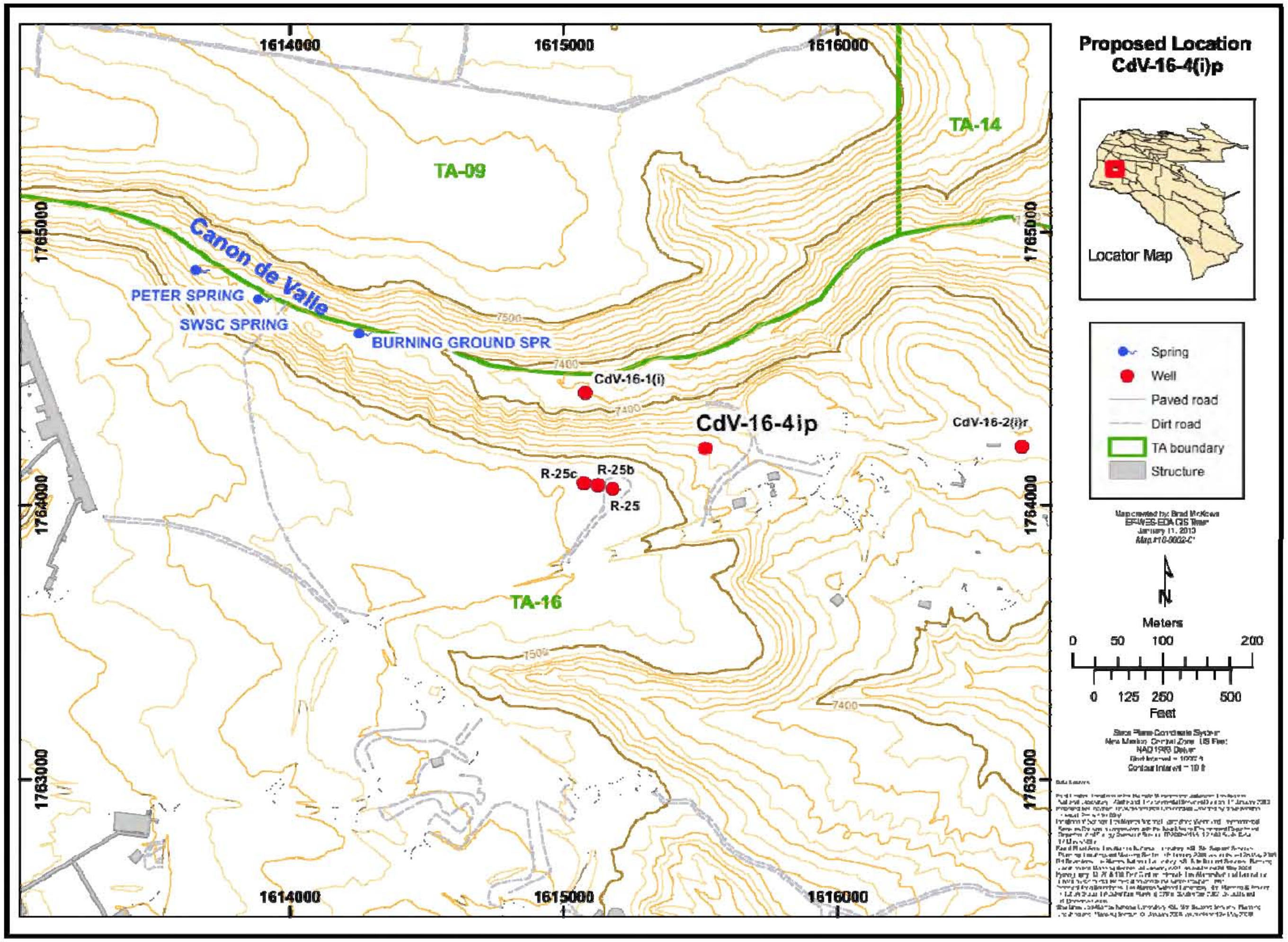


Figure 1. Location map for CDV-16-4ip showing locations of nearby monitoring wells.

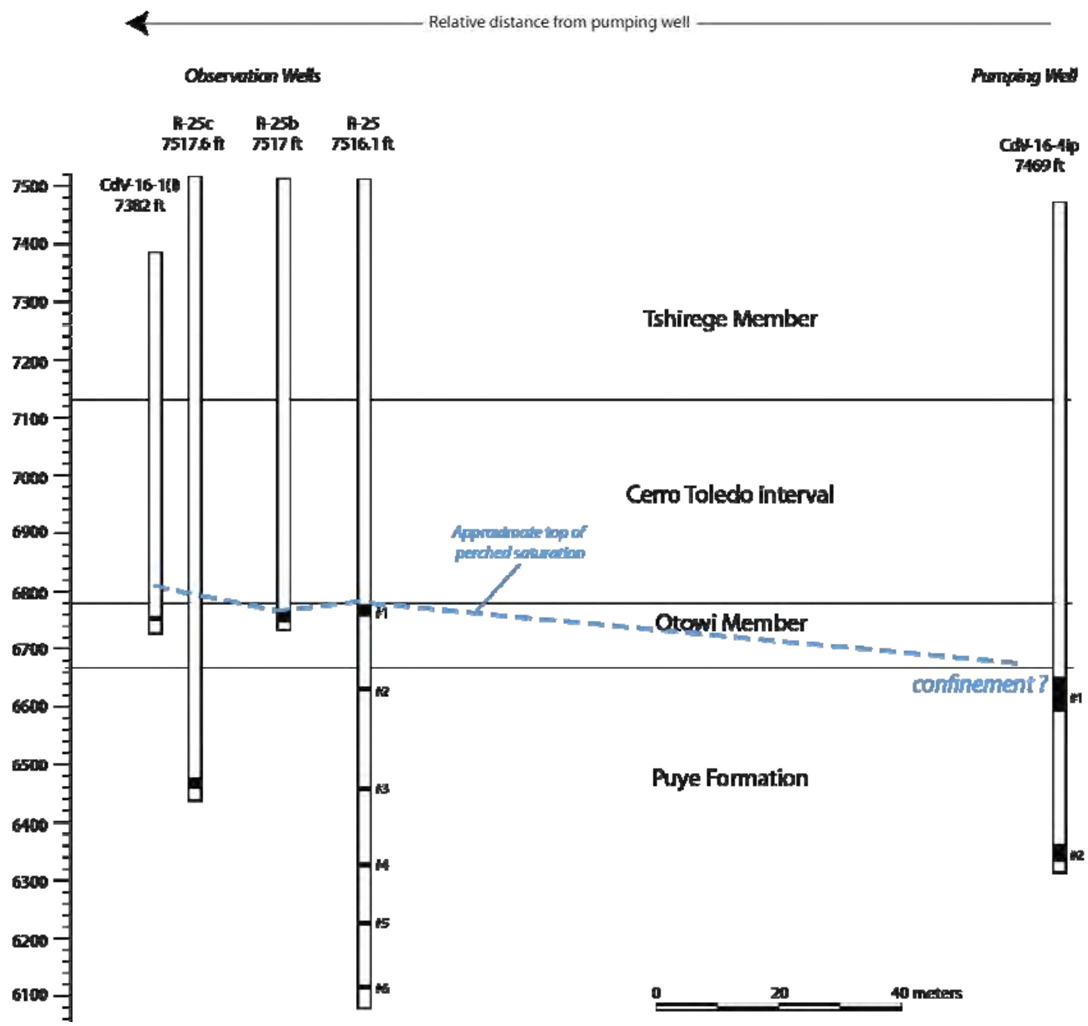


Figure 2. Pump test configuration showing locations of the proposed CdV-16-4ip well screens relative to the observation well screens.

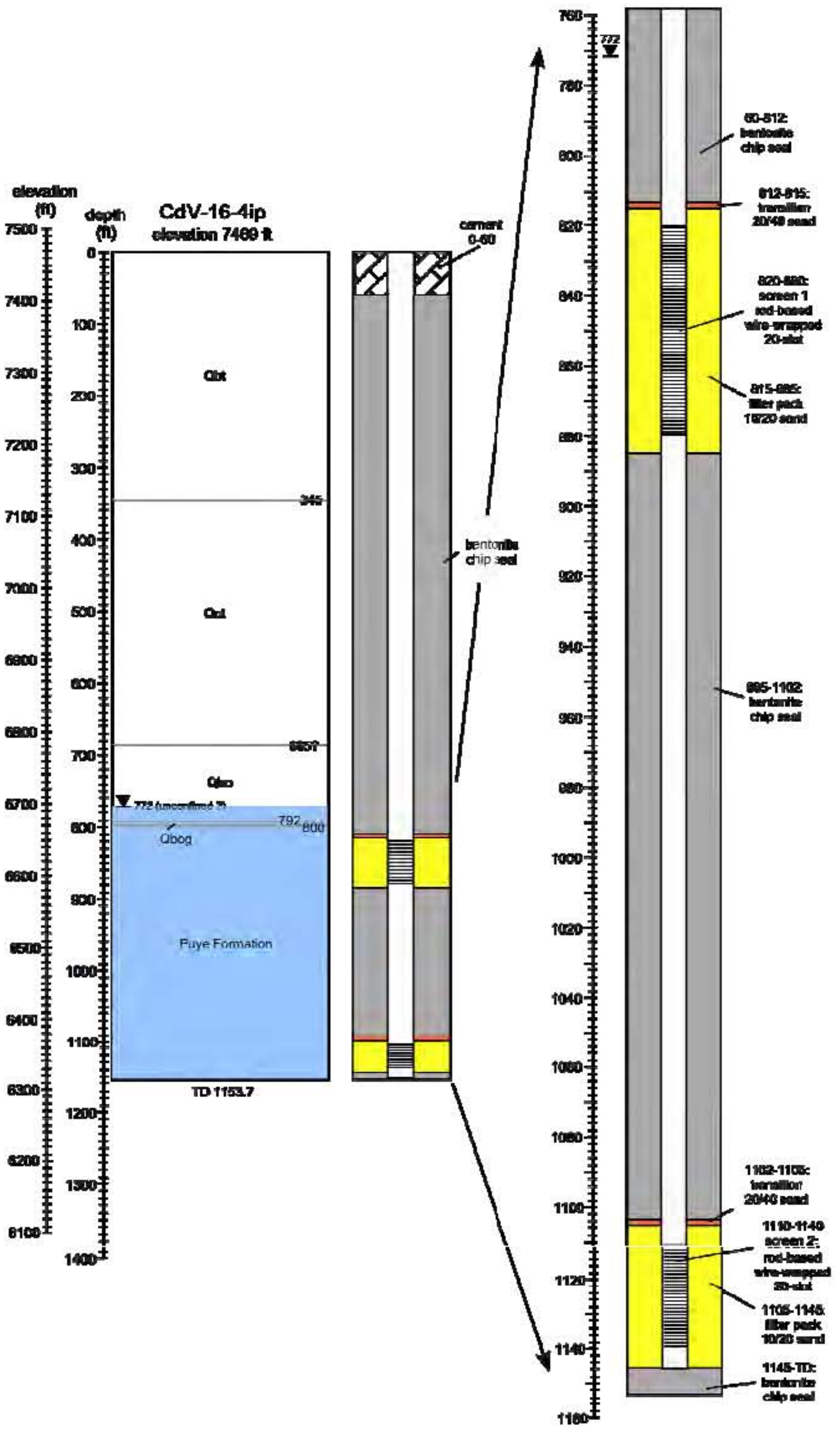


Figure 3. Proposed well design for CDV-16-4ip.

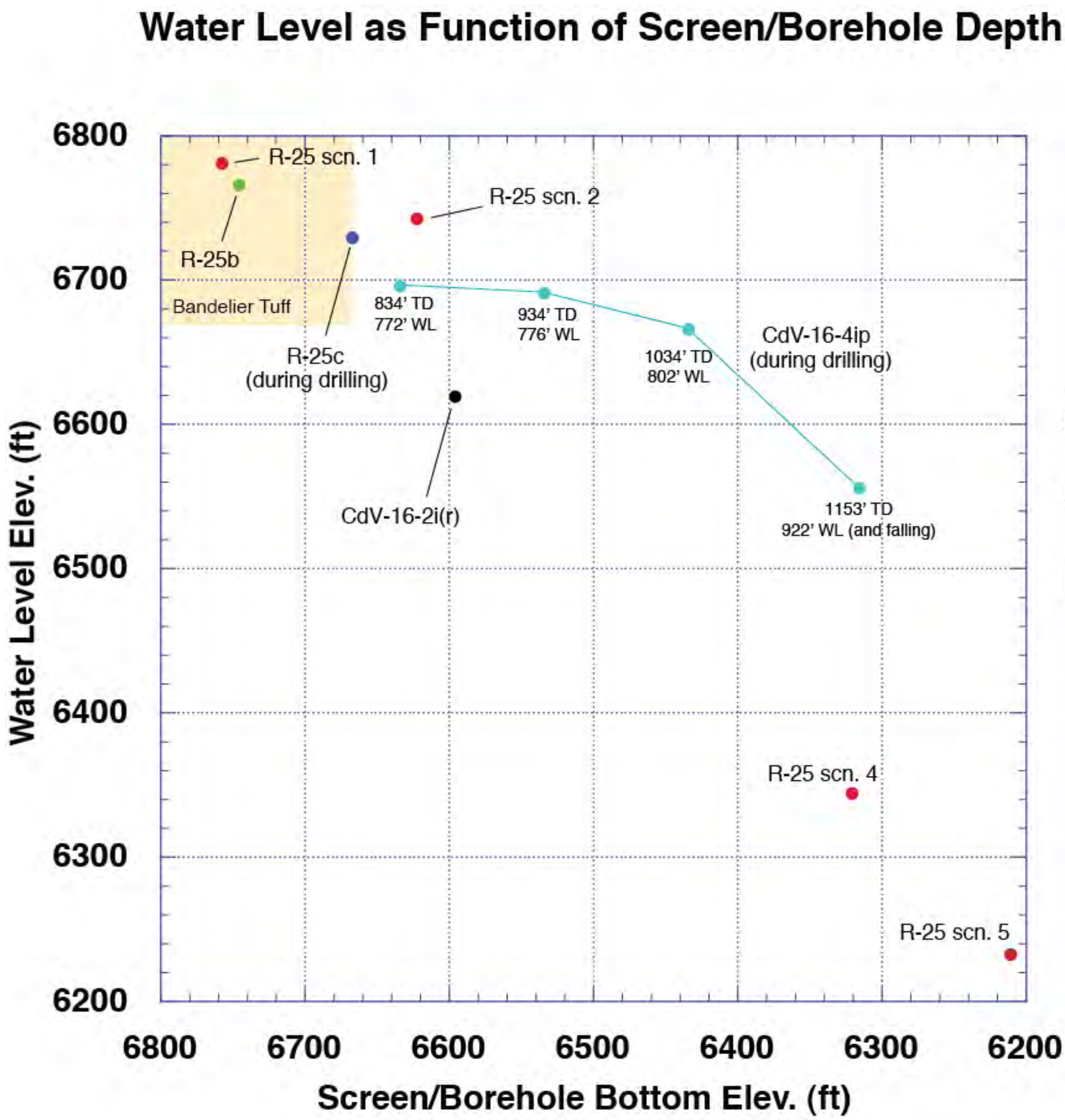


Figure 4. Water level elevations measured in the CDV-16-4ip open borehole during drilling and following water-level recovery tests. Water levels in nearby wells and boreholes are shown for reference.

From: Kulis, Jerzy, NMENV
To: Everett, Mark C; Cobrain, Dave, NMENV; Dale, Michael, NMENV
Cc: Shen, Hai; Mignardot, Edward R Jr; McCann, John P; Ball, Theodore T; Hickmott, Donald D; Lynnes, Kathryn D; Whitacre, Thomas J
Subject: RE: CdV-16-4ip proposed completion design
Date: Thursday, August 19, 2010 11:54:23 AM

Mark,

This e-mail serves as NMED approval for installation of intermediate aquifer well CdV-16-4ip as proposed in your e-mail sent on August 18, 2010 at 10:28 AM, with the following modification.

> The text of the proposed design for well CdV-16-4ip incorrectly states that screen 2 will be installed at 1105 to 1145 ft depth. Screen 2 shall be installed at 1110 to 1140 ft depth, in accordance with Figure 3 in the proposed design.

This approval is based on the information available to NMED at the time of the approval. NMED understands that LANL will provide the results of preliminary water-quality sampling, any modifications to the proposed well design, and any additional information related to the installation of well CdV-16-4ip as soon as such information becomes available. LANL shall give notice of this installation to the New Mexico Office of the State Engineer as soon as possible.

Thanks,

Jerzy Kulis
Environmental Scientist
Hazardous Waste Bureau
New Mexico Environment Department
2905 Rodeo Park Drive East, Bldg 1
Santa Fe, NM 87505-6303
Phone: 505-476-6039
Fax: 505-476-6030

From: Everett, Mark C [mailto:meverett@lanl.gov]
Sent: Wednesday, August 18, 2010 10:28 AM
To: Cobrain, Dave, NMENV; Kulis, Jerzy, NMENV; Dale, Michael, NMENV
Cc: Shen, Hai; Mignardot, Edward R Jr; McCann, John P; Ball, Theodore T; Hickmott, Donald D; Lynnes, Kathryn D; Whitacre, Thomas J
Subject: CdV-16-4ip proposed completion design

All,

The attached document includes the proposed design for well CdV-16-4ip and provides rational for the selected design. please respond to this e-mail with your concurrence or contact me to discuss further.

Thanks,

Mark Everett, PG
Drilling Project Technical Lead
LANL
(505) 667-5931 (office)
(505) 231-6002 (mobile)

Appendix D

Borehole Video Logging
(on DVDs included with this document)

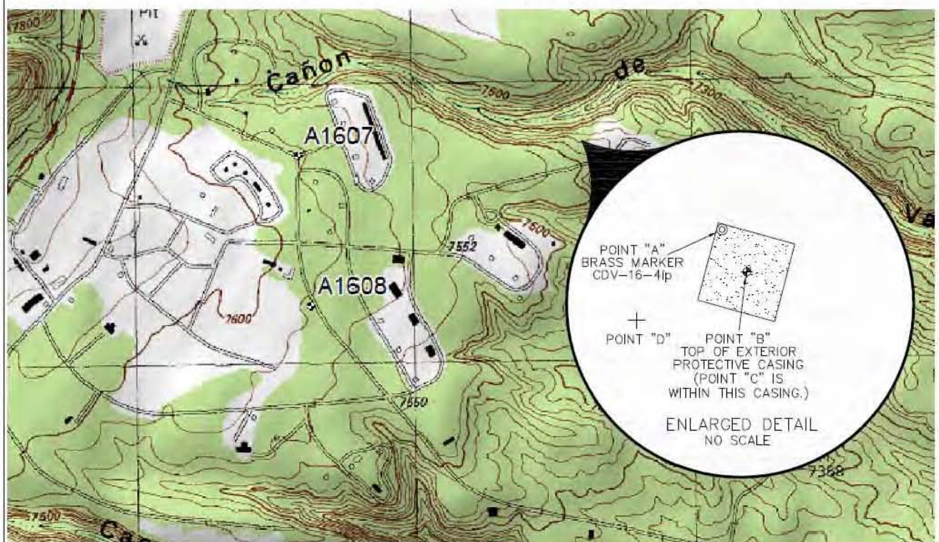
Appendix E

Geophysical Logging
(on CD included with this document)

Appendix F

Geodetic Survey Location Report

LANL MONITORING WELL LOCATION REPORT
DESIGNATED CdV-16-4ip
WITHIN TECHNICAL AREA 16
LOS ALAMOS NATIONAL LABORATORY
LOS ALAMOS COUNTY, NEW MEXICO
OCTOBER, 2010



POINT	DESCRIPTION	EASTING (X)	NORTHING (Y)	ELEVATION
A	BRASS MARKER CdV-16-4ip	1615587.07	1764195.74	7463.91
B	TOP OF 16" PROTECTIVE CASING	1615590.17	1764190.50	7467.35
C	TOP OF 5" WELL	1615590.17	1764190.43	7466.13
D	GROUND	1615576.60	1764184.46	7463.76

Notes

1.) FIELD SURVEY COMPLETED ON OCTOBER 14, 2010.

2.) THIS AREA LIES WITHIN LOS ALAMOS NATIONAL LABORATORY PROPERTY IN TECHNICAL AREA 16, LOS ALAMOS COUNTY, NEW MEXICO.

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

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

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

AUTHORITY:
THIS MONITORING WELL LOCATION REPORT WAS PREPARED FROM A SURVEY DONE UNDER MY SUPERVISION ON THE 14TH DAY OF OCTOBER, 2010 AND FROM INSTRUCTION PROVIDED TO US BY NORTH WIND, INC.

LARRY W. MEDRANO, N.M.P.L.S. NO. 11993

DATE 10/20/2010

LARRY W. MEDRANO
NEW MEXICO
11993
REGISTERED PROFESSIONAL SURVEYOR

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