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Completion Report for Well R-25c

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September 2008

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EXECUTIVE SUMMARY

This well completion report describes the drilling, installation, and testing of Los Alamos National Laboratory (the Laboratory) upper saturated zone well R-25c located on the mesa top in Technical Area 16 (TA-16), Los Alamos, New Mexico. This single-screen well at the R-25 location is set at depth in the upper saturated zone to replace Screen 3 in the existing well R-25. R-25 was installed to provide hydrogeology and water-quality data as required by the March 1, 2005, Compliance Order on Consent for environmental remediation at the laboratory. Well R-25c was installed to identify potential presence of perched groundwater and contamination in the upper saturated zone that may be associated with effluents containing high explosives that were discharged from the TA-16-260 Outfall.

The R-25c borehole was successfully drilled to a total depth (TD) of 1140 ft below ground surface and was terminated in the Puye Formation. A well was installed with a screen interval between 1039.6 and 1060.0 ft bgs. Cuttings were collected at 5-ft intervals from the ground surface to TD.

The drilling method for borehole R-25c was direct air-rotary and casing-hammer with water and foam assist, as needed, above the known saturation interval. Casing advance using the STRATEX system was used to drill below 610 ft.

A cased-hole suite of geophysical logs (0 to 610 ft) was completed in R-25c for hydrogeologic characterization. The well was completed in accordance with the NMED-approved well design.

Groundwater was not produced in R-25c, which is consistent with the previous observation that screen 3 dried out after completion of R-25. Because of lack of productivity, the well was not developed. The well and aquifer evaluation indicates the necessity to continuously monitor potential presence of seasonal groundwater in this zone.

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1.0 INTRODUCTION

This monitoring well completion report summarizes the site preparation, drilling, well construction, aquifer evaluation, and related activities completed to date for monitoring well R-25c. Monitoring well R-25c was drilled and completed in September 2008 at Los Alamos National Laboratory (LANL, or the Laboratory) for the Environmental Programs Water Stewardship Program.

The R-25 site is located on the mesa top in Technical Area 16 (TA-16) at the Laboratory (Figure 1.0-1). A detail of the R-25 site layout is shown in Figure 1.0-2. TA-16, also known as S-Site, contains many of the Laboratory's high explosives (HE) facilities, the Laboratory's state-of-the-art tritium facility, and several administrative support buildings. Activities involve fabricating and testing HE, plastics, and adhesives; conducting research in process development for manufacturing high explosives, plastics, adhesives and other materials; and tritium processing. In addition, several new buildings are under construction.

The existing R-25 well was installed to monitor for potential contamination in groundwater that may be associated with effluents containing HE that were discharged from an HE manufacturing facility outfall at TA-16-260. R-25 was completed in 1999 and includes nine separate screened intervals. The first three screen intervals (screens 1, 2, and 3) of R-25 are believed to be compromised (screen 3 was drilled out because of damage during installation, and screened intervals 1 and 2 appear to be impacted by the activities conducted in screen 3).

R-25c is intended to be a replacement well for the third screened interval (screen 3). Well R-25c was designed to monitor upper saturated zone water-quality data at 1040 to 1060 ft below ground surface (bgs). The purpose of monitoring well R-25c is to provide hydrogeology and water-quality data as required by the March 1, 2005, Compliance Order on Consent (the Consent Order) for environmental remediation at the Laboratory. A separate well (R-25b) is being installed to monitor the screen 1 interval in R-25. Activities related to R-25b are detailed in a separate well completion report. The location and placement of screened intervals in both wells (R-25b and R-25c) was at the direction of the New Mexico Environment Department (NMED), in accordance with the Consent Order.

The R-25c borehole was successfully drilled to a total depth (TD) of 1140 ft bgs and was terminated in the Puye Formation. A well was installed with a screen interval between 1039.6 and 1060.0 ft bgs. Cuttings were collected at 5-ft intervals from the ground surface to TD from the drill discharge hose.

Postinstallation activities including surface completion, dedicated water-level monitoring system installation, site restoration, and wellhead surveying will be completed and reported in an addendum to this report.

The information presented in this report was compiled from field reports and activity summaries. Records, including the field reports, field logs, and survey information are on file at the Laboratory Records Processing Facility. This report contains brief descriptions of all activities associated with the R-25c project as well as supporting figures, tables, and appendices.

2.0 PRELIMINARY ACTIVITIES

Preliminary activities included preparing administrative planning documents and improvements to the drill site (Figure 1.0-2).

2.1 Administrative Preparation

The following documents were prepared to guide the implementation of the scope of work for this well:

- "Drilling Work Plan for Well R-25c" (LANL 2008, 100696)
- "Storm Water Pollution Prevention Plan for R-25b and c Well Drilling Construction Site," Los Alamos National Laboratory document LA-UR-06-1840, Los Alamos, New Mexico (LANL 2008)
- LANL (Los Alamos National Laboratory), June 2008 "Waste Characterization Strategy Form for the R-25 Monitoring Well Installation" (Los Alamos National Laboratory document)
- The drilling work plan (February 2008), which includes the NMED-approved well completion design.

2.2 Site Preparation

Site preparation was performed from June 18 to June 30, 2008, and included implementation of best management practices in accordance with the Storm Water Pollution Prevention Plan. This included minimal clearing of vegetation and expansion of the existing R-25 pad and lay-down areas, excavating and lining cuttings containment pits, and installing berms, silt fences and straw waddles to control stormwater runoff and minimize erosion. An office trailer, sanitary facilities, and other general field equipment were also moved to the site during this time. The drill pad measured approximately 60 ft × 220 ft and was covered with base-course gravel.

Two cuttings pits were constructed on the R-25 site, one each for R-25c and R-25b. Each of these pits was constructed with a central berm so cuttings from above the saturated interval could be segregated from those below. This was done to potentially minimize the volume of cuttings requiring off-site disposal, because there is a reasonable expectation that the formation above saturation is not contaminated. The two R-25c cells each measured approximately 45 ft × 30 ft with an 8-ft average depth. The two pits were lined with plastic sheeting, 10 mm in thickness.

Radiation control technicians from the Laboratory's Radiation Protection Group-1 performed radiological screening of all construction equipment entering or leaving the S-Site limited access area, as necessary. All equipment or vehicles that were taken off-road or otherwise came into contact with soils were screened for HE by representatives from TA-16 Access Control before exiting from the S-Site limited access area.

Potable water used for drilling, dust suppression, and well installation was obtained from an existing Laboratory fire hydrant (#618) approximately 500 ft west of the site on Burning Grounds Road. The water was temporarily contained in a 2500-gal. water tank in the hull of the rod truck at the site.

Safety barriers and signs were installed around the borehole-cuttings containment pits and at the pad entrance.

On June 30, 2008, Water Development Corporation Wells and Exploration (WDC) mobilized drilling equipment to the site. On July 1, 2008, a decontamination pad was constructed and downhole equipment that would be used to advance the borehole was pressure washed with a steam cleaner using the potable water source. The Laboratory conducted a mast-up drill rig equipment inspection at the site before drilling activities began on July 2, 2008.

3.0 DRILLING ACTIVITIES

The proposed drilling method for borehole R-25c was direct air-rotary and casing-hammer with water and foam assist, as needed, above the expected saturation interval. Foam was not used to advance the borehole within approximately 100 ft of the saturated interval. The borehole was completed using a Failing Co. Speedstar 50K drill rig (Rig 111). Air used for drilling the borehole was provided by one deck mounted 900 cubic foot per minute (cfm) compressor and two trailer mounted auxiliary air compressors.

On July 2, 2008, a 16-in.-outside-diameter (O.D.) permanent surface conductor casing (¼-in. thick steel) was set to 19.8 ft bgs and was grouted in place. On July 7 and July 8, 2008, the open borehole was advanced to 150 ft bgs with a button bit, downhole hammer, roller stabilizer, and drill collar assembly using air and water to operate the hammer and lift the drill cuttings. From July 9 to July 11, 2008, the open hole was advanced from 150 to 610 ft bgs with the same equipment; however, approved drilling foam (Baroid AQF-2) was added to the injected water to aid in lifting the drill cuttings to the surface. No drilling fluid other than water was used within 100 ft of the potential saturated horizon.

In order to address circulation and borehole stability problems, steel casing (11 ¾ in. O.D.) was set from the surface to 610.3 ft bgs. Before casing the borehole, the Laboratory performed a video, a natural gamma ray, and an induction survey of the open borehole from the surface to 609.2 ft bgs on July 12, 2008.

On July 15 and July 16, 2008, WDC advanced the borehole from 610 to 695 ft bgs using a 10 ⅝-in.-diameter downhole hammer assembly consisting of a button bit, hammer, roller stabilizer, and two drill collars. The downhole hammer assembly became disengaged at a depth of approximately 640 ft bgs. WDC successfully retrieved the entire assemblage on July 27, 2008.

From July 28 to August 5, 2008, WDC crew removed the 610 ft of drive casing, replaced the existing drive shoe with the STRATEX drive shoe and lowered the casing into the borehole to a depth of 634 ft. The STRATEX casing bit overreams the borehole to approximately 13 ¼-in. diameter. In order to employ the STRATEX system, a 9 ⅝-in. tri-cone mill toothed bit was used to drill/drive the bit and casing to 674 ft using the casing hammer. The STRATEX system was then used to drive casing to 848.5 ft.

On August 10, 2008, a 9 7/8-in. O.D. downhole hammer was used to drill the borehole to 1080 ft bgs in an uncased hole.

Due to low penetration rates, an 8 ¾-in. O.D. milltooth tricone bit and drill collar assembly was used to advance the borehole from 1080 to a final TD of 1140 ft. The borehole was drilled 60 ft beyond the planned TD of the completed well (1100 ft) to provide room for potential sloughing of the formation material. While retracting the drill string, the bit and the 20-ft long collar were lost at the bottom of the borehole.

On August 13, 2008, the Laboratory ran a downhole video log of the borehole to 951 ft, where the presence of a rock ledge prevented further camera advancement. That same afternoon, Schlumberger conducted additional geophysical surveys in the cased borehole to a depth of 850 ft bgs.

On August 13, 2008, the Laboratory decided that there should not be an attempt to recover the bit and collar lost in the borehole due to borehole stability issues encountered previously and the fact that the tools were located more than 40 ft below the planned well screen interval. Clearing of the borehole in preparation for well construction resumed. An 8 ¾-in. O.D. tricone bit was used to clear the borehole to 1100 ft bgs.

On August 14, 2008, the Laboratory ran a video survey of the borehole to a depth of 933 ft. The camera could not be advanced below this interval due to an apparent cobble partially obstructing the borehole. Schlumberger then ran survey instruments down the borehole and was unable to advance beyond 911 ft. Schlumberger completed the cased survey suite in the interval above the obstruction. The Laboratory made a second attempt to video log the borehole but could not advance below an obstruction at 901 ft bgs.

The Laboratory decided initially to complete the shallower well R-25b in this borehole due to the borehole stability problems that were being encountered. On August 14, 2008, WDC again advanced the borehole with the 8 ¾-in. tricone bit to clear out any sloughed material and protruding cobbles or other obstructions, lowered the tremie pipe to 1100 ft bgs and backfilled the borehole with a bentonite seal above the abandoned drill bit and drill collar from TD of approximately 1140 to 1096.5 ft. A sand lift (10/20 Colorado silica sand) was emplaced via tremie from 1096.5 to 879 ft bgs. Subsidence of backfill materials was noted, indicating that the borehole diameter was greater than the expected diameter. (The actual diameter of the borehole in this interval is unknown, although video and drilling observations within the Puye Formation, to the maximum depth of approximately 910 ft bgs, confirm uneven borehole dimensions because of the presence of cobbles and boulders apparently plucked during drilling advancement.)

On August 15, 2008, a 50/50 mixture of bentonite and sand was used to backfill the borehole from 879 to 800 ft bgs, in anticipation of completing the borehole as R-25b. This plan was reevaluated; on August 19, 2008, it was decided to readvance and enlarge the borehole to 1080 ft bgs using the 11 ¾-in.-drive casing (overreams to a 13 ¼-in.-diameter borehole) and construct R-25c as originally designed.

On August 22, 2008, the readvancement of the borehole was completed at a TD of 1080 ft bgs. During the readvancement, there was no visual evidence of bentonite present below the interval that the bentonite grout was placed (800 to 879 ft bgs) during the backfilling activities. Well construction activities commenced.

4.0 SAMPLING ACTIVITIES

This section describes the cuttings and groundwater sampling activities at R-25c.

4.1 Cuttings Sampling

Cuttings samples were collected from R-25c at approximately 5-ft intervals from the ground surface to the total depth of 1140 ft bgs. A bulk sample of varying volumes was collected from the discharge hose. Sieved fractions (>#10 and >#35 mesh) were retained in chip trays along with an unsieved (whole rock) fraction. The remaining sample material was sealed in ziplocked bags, labeled, and archived in core boxes for eventual transfer to the Laboratory Geology task leader. No cuttings samples were submitted for laboratory analysis.

4.2 Water Sampling

No water samples were collected during the drilling of monitoring well R-25c.

5.0 GEOLOGY AND HYDROGEOLOGY

A brief description of the geologic and hydrogeologic features encountered at R-25c is presented below.

The Laboratory's geology task leader and site geologists used cuttings examination along with Laboratory and Schlumberger geophysical logs to determine the geologic contacts. Drilling observations, video logging, water-level measurements, and geophysical logs were used to describe groundwater characteristics encountered at R-25c.

5.1 Stratigraphy

Borehole stratigraphy for the R-25c borehole is presented below in order of youngest to oldest geologic units. Figure 5.1-1 illustrates the stratigraphy at R-25c. A detailed lithologic log is presented in Appendix A.

Quaternary Alluvium, Qal (0 to 5 ft bgs)

Quaternary alluvium consisting of poorly to moderately sorted loose sand was encountered from 0 to 5 ft bgs. No evidence of alluvial groundwater was observed.

Tshirege Member of the Bandelier Tuff, Qbt (5 to 384 ft bgs)

Four subunits of the Tshirege Member of the Bandelier Tuff—Qbt 1, Qbt 2, Qbt 3, and Qbt 4—were encountered at R-25c from 5 to 384 ft bgs. Qbt 1 and Qbt 3 have been further subdivided, as indicated below.

Qbt 4 was present from 0 to 84 ft bgs. It consisted of a pale yellowish brown to light brownish gray, non to moderately welded crystal-rich devitrified ash-flow tuff. Cuttings from this interval typically contained fine ash matrix material with abundant quartz and sanidine crystals, and minor intermediate composition volcanic lithics.

The interval from 84 ft to 228 ft bgs includes an upper subunit Qbt 3t, with chemical properties that are transitional between lower Qbt 3 and Qbt 4. Qbt 3t and Qbt 3 were present in the R-25c borehole from 84 to 155 ft bgs and from 155 to 228 ft bgs, respectively. Both units are composed of a pale yellowish brown, brownish black, or medium gray, nonwelded to moderately welded, devitrified, crystal-rich ash-flow tuff and are mineralogically and texturally similar. Cuttings samples contained abundant welded, crystal-rich tuff with quartz and sanidine phenocrysts and generally minor quantities of intermediate composition volcanic lithics and feldspar crystals.

Qbt 2, from 228 to 332 ft bgs, is a grayish-brown to grayish-red, moderate to strongly welded, crystal-rich devitrified ash-flow tuff. Samples are generally composed of crystal-rich tuff fragments and quartz and sanidine crystals. Occasional intermediate to mafic composition volcanic lithics and vapor-phase altered pumice fragments are also observed.

The basal-cooling unit of the Tshirege Member is divided into an upper devitrified (Qbt 1v) and lower glassy (Qbt 1g) subunit (Broxton and Reneau 1995). Qbt 1v was present from 332 to 369 ft bgs as a grayish-brown to dusky brown, nonwelded to partially welded, devitrified, ash-flow tuff. Matrix tuff fragments are crystal rich with quartz and sanidine crystals. Rare mafic composition volcanic lithic fragments and minor vapor-phase altered pumice were observed. Qbt 1g was present from 369 to 384 ft bgs as a medium gray, non welded, devitrified ash-flow tuff. Pinkish-gray fibrous vitric pumice was common.

Cerro Toledo Interval, Bandelier Tuff, Qct (384 to 740 ft bgs)

Volcaniclastic sedimentary and tephra deposits of the Cerro Toledo interval separate the Tshirege and Otowi Members of the Bandelier Tuff. The Cerro Toledo interval occurred in borehole R-25c from 384 ft to 740 ft bgs.

This interval contained poorly sorted uncemented fine to coarse grained deposits of sand and fine gravel. Clasts are predominantly angular to rounded dacitic and rhyolitic flows, vitric pumice, nonwelded tephras, and abundant felsic crystals including bipyramidal quartz and sanidine. Rare fine sandstone was also observed. Clasts are generally light to dark gray and reddish brown. Pumice and tephras are light brown and white or orange where oxidized. The presence of quartz and sanidine crystals, up to 2 mm in diameter, indicates that the Cerro Toledo interval includes a component of reworked Otowi Member tuff.

Otowi Member of the Bandelier Tuff, Qbo (740 to 843 ft bgs)

The Otowi Member of the Bandelier Tuff is present in R-25c from 740 to 843 ft bgs. The Otowi Member is a lithic-bearing, partly pumiceous, and nonwelded ash-flow tuff. It contains reddish gray to gray, subangular to subrounded, intermediate composition volcanic rocks up to 15 mm. Pale yellow to white pumice lapilli are vitric and contain conspicuous phenocrysts of quartz and sanidine.

Guaje Pumice Bed of the Otowi Member of the Bandelier Tuff, Qbog (843 to 850 ft bgs)

The Guaje Pumice Bed is present from 843 to 850 ft bgs and contains white pumice lapilli containing quartz and sanidine phenocrysts and trace mafic minerals.

Puye Formation, Tpf (850 to 1140 ft bgs)

The Puye Formation consisted of poorly sorted volcaniclastic boulder, and gravel deposits from 850 to 1140 ft bgs. Clasts consist of subangular to angular dacitic volcanics with conspicuous felsic and mafic phenocrysts. Minor clayey and silty intervals are also present. The formation ranges from very light gray to dark gray with some dusky red clasts.

5.2 Groundwater

Groundwater was recognized in R-25c during drilling at approximately 848 ft bgs near the Guaje Pumice Bed-Puye Formation contact. The composite water level when the drill casing was advanced to 850 ft bgs was 787 ft bgs. Upon completion and aquifer evaluation, no groundwater was observed within the well.

6.0 BOREHOLE LOGGING

A suite of cased-hole geophysical logs (conducted by Schlumberger) and multiple downhole video and natural gamma surveys (conducted by the Laboratory) were run during the drilling and installation of R-25c. A summary of video and geophysical logging runs is presented in Table 6.0-1.

6.1 Video Logging

The initial video log run conducted in the open borehole is presented on a digital video disk in Appendix C. Additional video logs were collected to evaluate borehole conditions during advancement and following well installation but are not presented in this report because only logs that documented geological and groundwater features are included. Table 6.0-1 details individual video logging runs.

- The Laboratory completed a video survey of R-25c on July 12, 2008, before casing the borehole to 610 ft. The borehole was open to 609.2 ft, and less than a foot of water (likely fluids introduced during drilling) was observed in the bottom of the borehole. Perched groundwater was not observed entering the borehole at any depth on the video log.
- On August 13, 2008, the Laboratory ran a video survey of R-25c in an attempt to locate a tricone bit and a 20-ft-long drill collar that had come unthreaded from the drill string while tripping out of

the hole. This run was discontinued at 910 ft bgs because of the presence of a rock ledge that prevented advancement of the camera. The drill casing was at 850 ft bgs and the water level in the borehole was observed at 784 ft bgs.

- On August 14, 2008, having redrilled the borehole to 1100 ft bgs, the Laboratory ran a video survey of the borehole and was unable to advance the camera past 933 ft bgs. Schlumberger arrived at the site to perform geophysical logging of the borehole. The Laboratory made a second attempt at video logging the same day; however, an obstruction was encountered at 901.1 ft bgs, and video logging could not proceed below this depth. Drill casing was at 850 ft bgs, and the water level in the borehole was observed at 808.1 ft bgs.
- On September 11, 2008, the Laboratory conducted a video survey of the interior of the well casing. The video survey indicated the top of the well screen was located at 1040.1 ft bgs and the water level was 1058.3 ft bgs, 2 ft above the bottom of the well screen. The well screen was in good condition and free of any apparent obstructions.
- On September 18, 2008, the Laboratory conducted another video survey of the interior of the well casing. At this time bentonite grout was observed to have infiltrated the screen interval from the top (1040 ft bgs) to a depth of approximately 1053 ft bgs. The remainder of the screen (1053 to 1060 ft bgs) showed no sign of bentonite infiltration.
- On September 23, 2008, the Laboratory conducted another video survey of the interior of the well casing after the well had been swabbed and bailed with 100 gal. of water. The well screen appeared clean and no signs of bentonite seepage.

6.2 Geophysical Logging

- On July 12, 2008, the Laboratory ran a natural gamma ray and an induction log of the uncased R-25c borehole to 609.1 ft bgs (in addition to performing a video log of the borehole).
- A suite of Schlumberger geophysical logs was run inside the drill casing of R-25c on August 13 and August 14, 2008. At the time of logging, the bottoms of the two casing strings in the R-25c borehole were located at the following depths:
    - ❖ bottom of 16-in. casing: 19.8 ft bgs
    - ❖ bottom of 11.75-in. casing: 848.5 ft bgs
- On August 13, 2008, the Schlumberger geophysical suite included hostile natural gamma spectroscopy (HNGS) and elemental capture spectroscopy (ECS). HNGS was run up hole inside the casing from 850 to 700 ft bgs. ESC was run up hole inside the casing from 850 to 600 ft bgs.
- On August 14, 2008, the geophysical suite included triple lithodensity detector (TLD) and accelerator porosity sonde (APS). Both were run up hole inside the casing from 850 to 600 ft bgs.
- On September 11, 2008, the Laboratory conducted a natural gamma ray survey of the interior of the well casing from 1000 to 1085 ft bgs.

The final Schlumberger logs and report will be included in the R-25b well completion report because they are pertinent to the screened interval of well R-25b. The geophysical logging data collected on July 12, 2008, by the Laboratory and preliminary Schlumberger montage are included in Appendix B.

7.0 WELL INSTALLATION

R-25c well casing and annular fill were installed between August 22 and September 17, 2008.

7.1 Well Design

The R-25c monitoring well was designed in accordance with the Consent Order. The well design was approved by NMED (February 2008). The well was constructed with a single screened interval (1040 to 1060 ft bgs) to replace screen 3 in well R-25.

7.2 Well Construction

The R-25c well casing was constructed of 5.0-in. inside diameter (I.D.)/5.563-in. O.D. 304 (non-API) stainless-steel blank casing joints fabricated to American Society for Testing and Materials (ASTM) A312 standards. Casing ends, screen ends, and couplings were threaded with 5-in. 8-round short-casing threads in compliance with American Petroleum Institute Standard 5B. The well screen consists of two consecutive 10-ft lengths of 5.0-in.-I.D./5.563-in.-O.D. rod-based 0.020-in. (slot size) wire-wrapped well screen. The casing and screen were factory cleaned and also steam cleaned on-site. R-25c was constructed with a screened interval 1039.6 to 1060.0 ft bgs. A 20.35-ft long piece of blank well casing was placed below the well screen for a sump. Figure 7.2-1 shows construction details for the completed well.

On August 22, 2008, well construction began with the placement of a 2-in.-inside diameter steel integral joint tremie pipe in the borehole to a depth of 1060 ft bgs. The tremie pipe was used to deliver all annular fill materials during well construction.

The borehole had been readvanced to approximately 1083 ft bgs (which was within the interval previously backfilled with 10/20 Colorado silica sand, following sealing off the drill bit and collar with a bentonite plug below 1100 ft bgs). Five feet of 20/40 sand was placed from 1083 to 1078 ft bgs. An 8-ft bentonite/sand seal was installed around the well sump from 1078 to 1070 ft bgs.

The primary filter pack of 10/20 silica sand was placed from 10 ft below the bottom of the screened interval to 5.5 ft above the top of the screen (1070 to 1034 ft bgs). The screened interval was set from 1039.6 to 1060 ft bgs. A transition sand collar of 20/40 silica sand was then placed above the primary filter pack from 1036 to 1034 ft bgs. Following placement of the fine sand collar, the drill crew installed another bentonite seal (bentonite chips with 10/20 sand added to aid emplacement) from 1032 to 844 ft bgs to protect the well screen from the bentonite slurry being placed above the seal.

Upon completing the placement of the bentonite chip/sand seal to 844 ft, the drill crew began backfilling the annular space from 844 to 368.5 ft bgs with a high-solids bentonite grout.

On August 26, 2008, well completion operations were temporarily suspended. On September 13, well completion activities resumed. Observations made by the well construction crew confirmed earlier observations that the borehole diameter was in excess of 13.3 in. due to the higher than calculated volume of grout required to bring the backfill to depth. In order to seal the borehole more effectively, from 368.5 to 75 ft bgs bentonite chips were placed in the annulus and hydrated after approximately every 10 ft. lift. A bentonite cement seal was placed from 75 to 2 ft bgs. Well construction was complete on September 17, 2008. Water level was measured at 1074.33 ft bgs. Figure 7.2-1 depicts depths and volumes used in each interval. Table 7.2-1 details volumes of materials used during well construction.

8.0 POSTINSTALLATION ACTIVITIES

A wellhead surface pad will be installed at the well location and a geodetic survey will be performed following completion of well R-25b. Site restoration activities will commence once the final disposition of drill cuttings and groundwater is determined in accordance with the NMED-approved waste-decision trees.

8.1 Well Development

Well development began on September 12, 2008. Initially, the screen was bailed and swabbed to remove formation fines in the filter pack. The well bailed dry after removing approximately 18 gal. of water. A transducer was installed to aid in evaluating well response. The well was allowed to recover for six days. There was no measurable water level recovery. The Laboratory decided to discontinue any further development activities.

8.2 Aquifer Evaluation

During well completion, the water level was only 2 feet above the bottom of the screen. A baildown recovery test was conducted from September 12–17, 2008. The well did not recover. Another slug test was conducted on September 23–24 (after the infiltrated bentonite had been cleared from the screened interval) to evaluate the hydraulic properties of the screened zone. Water was added to bring the fluid level up into the screened interval but no appreciable fluid loss was noted. On September 24, 2008, 966 gal. of water was introduced to the well, and was lost to the formation before the well could be tagged. Following this test, another 100 gal. of water was introduced to the well. The formation readily accepted water, but water levels did not rise to a static level; therefore it was concluded that the zone is essentially nonproductive or seasonally productive.

8.3 Dedicated Monitoring System Installation

A dedicated in situ transducer will be installed in a polyvinyl chloride (PVC) tube to continuously monitor for the presence of water in this zone. The transducer tube is 1.0-in.-I.D. flush-threaded PVC with a 6-in. 0.010-in. screen-slot interval at the bottom of each tube. The transducer tubes are capped on the bottom below the screen. Post installation construction and monitoring component installation details for R-25c will be added to Figure 8.3-1 in the addendum to this report. See also the technical notes for R-25c.

8.4 Wellhead Completion

A reinforced concrete surface pad, 10 ft × 10 ft × 6 in. thick, will be installed at R-25c. The pad will provide long-term structural integrity for the well. A brass survey pin will be embedded in the northwest corner of the pad. A 10-in.-I.D. steel protective casing with a locking lid will be installed around the well riser. The concrete pad will be slightly elevated above the ground surface, with base-course gravel graded up around the edges.

8.5 Geodetic Survey

Geodetic survey data for the well casing top cap, protective casing, brass pin, and ground surface at R 25c will be collected upon wellhead completion. The survey data will be presented in Table 8.5-1 in the addendum as well as in the R-25b well completion report.

8.6 Site Restoration and Waste Management

Fluids and cuttings produced during drilling and development were containerized and sampled in accordance with the 2008 “Waste Characterization Strategy Form for the R-25 Monitoring Well Installation” (LANL 2008, 65053-001-08), prepared for the R-25 well drilling at the Laboratory. Characterization samples of the various waste streams will be collected and a summary of the samples collected and the analytical results for the R-25c well will be presented in Table 8.6-1 in the addendum.

Fluids and solids produced during drilling and well development are anticipated to be land-applied after review of associated analytical results per the waste characterization strategy form and the Laboratory Environmental Protection Directorate Standard Operating Procedure 010.0, Land Application of Groundwater in accordance with the "NOI Decision Tree" (revised July 26, 2006). NMED approval was received via letter dated November 21, 2006 ("NOI Decision Tree: Drilling, Development, Rehabilitation and Sampling Purge Water," November 2006, and/or "NOI Decision Tree For Management of Investigation-Derived Waste Solids from Drilling Operations," November 2007. Solids produced during drilling are anticipated to be used to restore the areas of the cuttings pits to grade. Both liquid and solid land application will be conducted in accordance with the approved decision trees.

Waste generation and characterization for the R-25c project include a small quantity of contact waste, decontamination fluids, cuttings, discharged drilling water, and purged groundwater. Additionally, one drum of New Mexico special waste was generated following a release of hydraulic oil from a broken line on one of the air compressors. The waste material consisted of adsorbent cloth and soil with the fluids. Analysis of the material indicated trace amounts of hydraulic oil and diesel fuel. The drum has been profiled and is scheduled for pickup on October 1, 2008, and disposed as New Mexico special waste.

Site restoration activities will include removing water from the cuttings containment pits and land-applying it on-site, in accordance with the decision tree, removing cuttings from the cuttings containment pits, removing the polyethylene liner, removing the containment area berms and backfilling, and regrading the containment area. Cuttings will be used in accordance with governing documents outlined above. The site will be reseeded with a native seed mix consisting of Indian rice grass, mountain broam, blue stem, sand drop, and slender wheat grass seed. The seed mix will be applied at a rate of 20 lb/acre. Biosol fertilizer will be applied at a rate of 80 lb/acre.

9.0 DEVIATIONS FROM PLANNED ACTIVITIES

In general, drilling, sampling, and well construction at R-25c was performed as specified in the "Drilling Work Plan for Well R-25c" (Laboratory 2008).

9.1 Deviations

- During well construction, a bentonite seal was placed in the bottom of the borehole to seal off the bit and collar left in the borehole.
- Bentonite chips were added to the annulus and hydrated from 368 to 75 ft after significant amount of the bentonite grout slurry being tremmied into annulus was lost to the formation.
- Because of the low productivity of the completion zone, well development was not possible. Water level will be monitored for one year and the utility of the well will be reassessed.

9.2 NMED-Approved Modifications to the Work Plan

No modifications were made to the original well construction design.

10.0 ACKNOWLEDGMENTS

Schlumberger conducted cased-borehole geophysical surveys.

WDC drilled the R-25 borehole and installed the well.

Enviroworks prepared the site for drilling activities.

Cabrera Services, Inc. provided management and oversight on all preparatory, reporting, and field-related activities.

Kleinfelder provided geologic field support and technical oversight and input related to drilling and aquifer evaluation, as well as preliminary report preparation.

11.0 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 number. This information is also included in text citations. ER ID numbers are assigned by the Environmental Programs Directorate's Records Processing Facility (RPF) and are used to locate the document at the RPF and, where applicable, in the master reference set.

Copies of the master reference set are maintained at the NMED Hazardous Waste Bureau; the U.S. Department of Energy–Los Alamos Site Office; the U.S. Environmental Protection Agency, Region 6; and the Directorate. The set was developed to ensure that the administrative authority has all material needed to review this document, and it is updated with every document submitted to the administrative authority. Documents previously submitted to the administrative authority are not included.

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

LANL (Los Alamos National Laboratory), March 22, 2007. "Waste Characterization Strategy Form for the R-35 Monitoring Well Installation," Los Alamos, New Mexico. (LANL 2007, 095170)

LANL (Los Alamos National Laboratory), February 2008. "Drilling Work Plan for Well R-25c," Los Alamos National Laboratory document LA-UR-08-0337, Los Alamos, New Mexico. (LANL 2008, 100696)

LANL (Los Alamos National Laboratory), June 2008. "Storm Water Pollution Prevention Plan for R-25b and c Well Drilling Construction Site," Los Alamos National Laboratory document LA-UR-06-1840, Los Alamos, New Mexico. (LANL 2008)

LANL (Los Alamos National Laboratory), June 2008 "Waste Characterization Strategy Form for the R-25 Monitoring Well Installation" Los Alamos National Laboratory document (LANL 2008, 65053-001-08), Los Alamos, New Mexico.

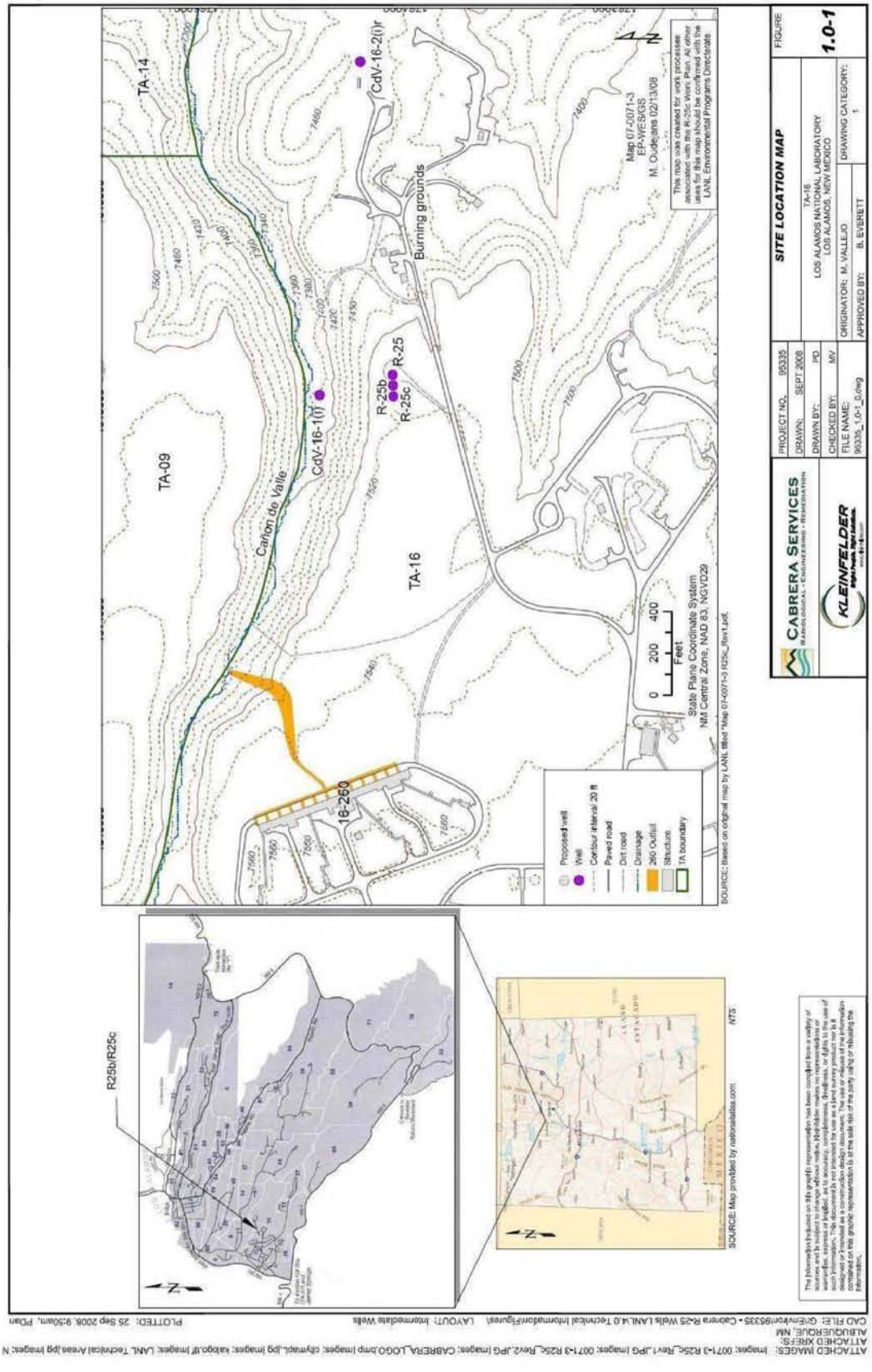

Figure 1.0-1 Site location map

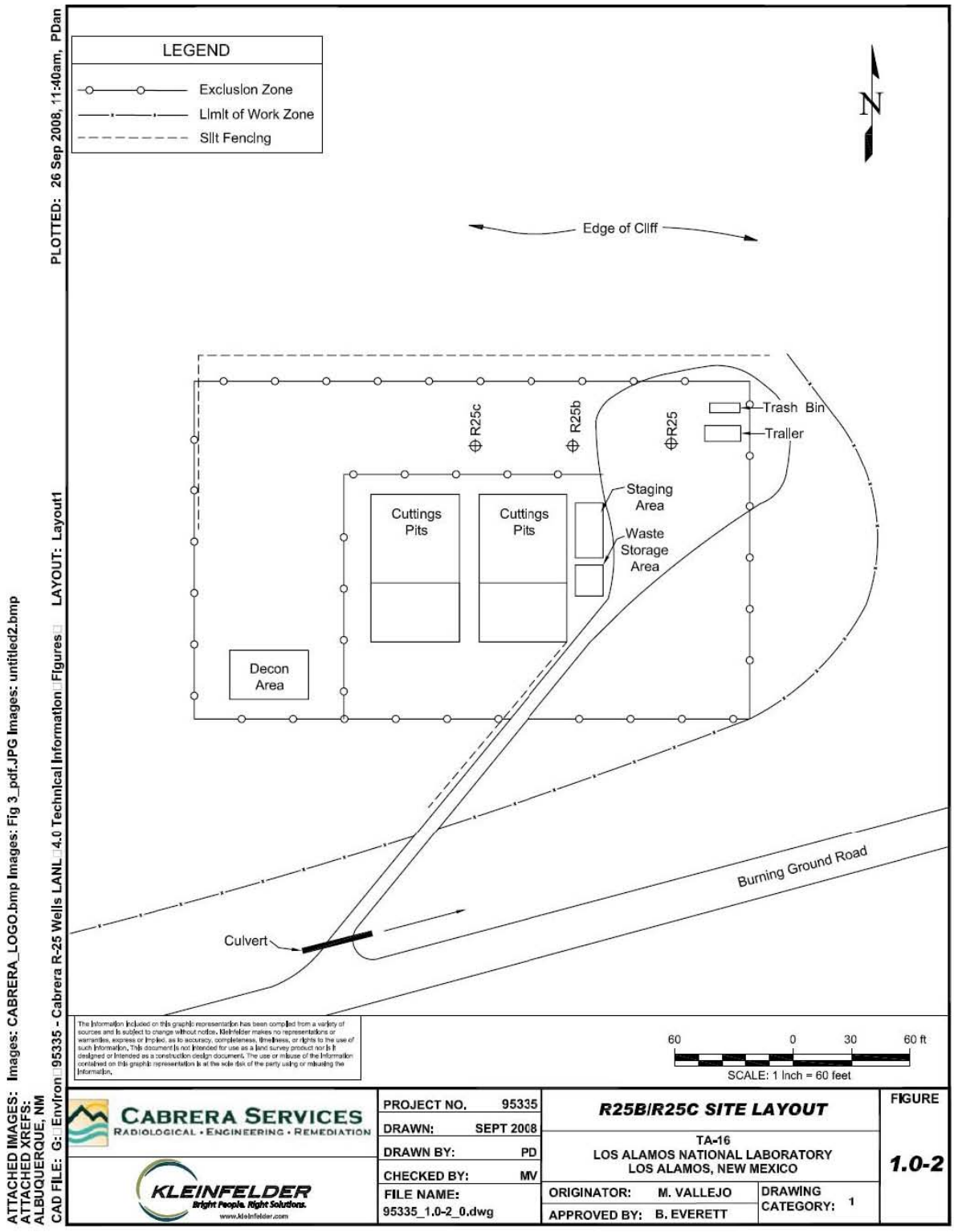

Figure 1.0-2 Site layout

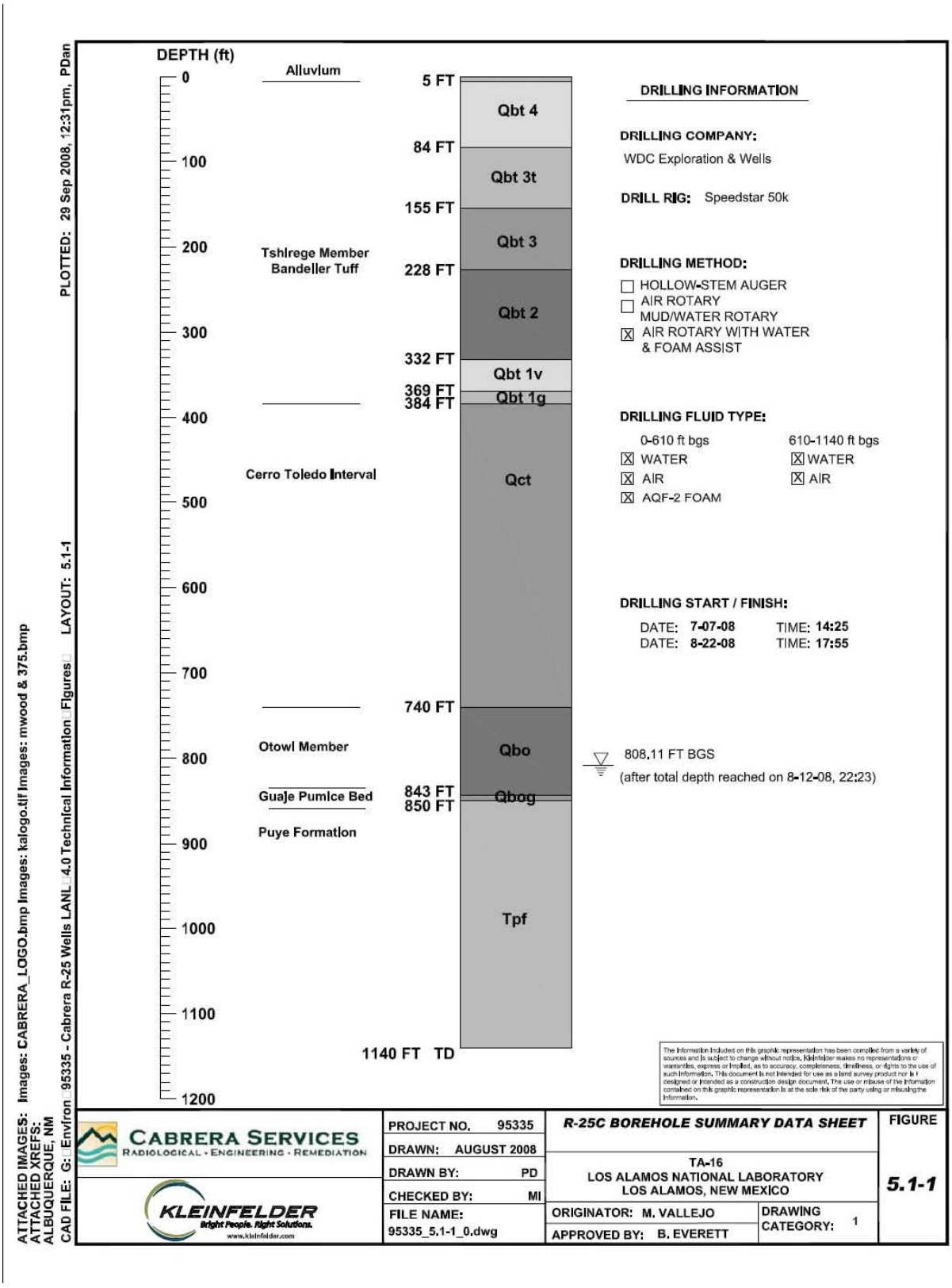

Figure 5.1-1 R-25c borehole summary data sheet

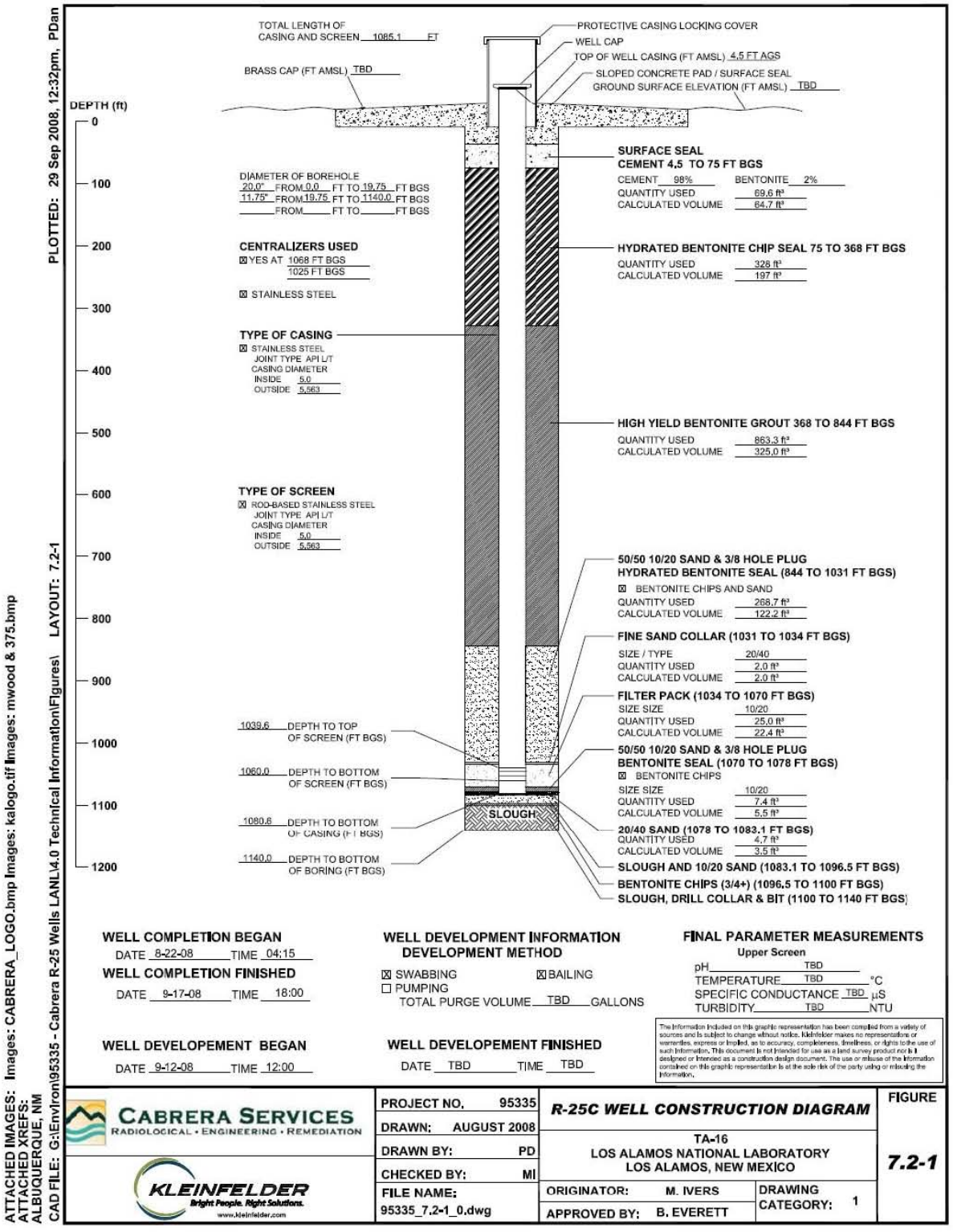

Figure 7.2-1 R-25c well construction diagram

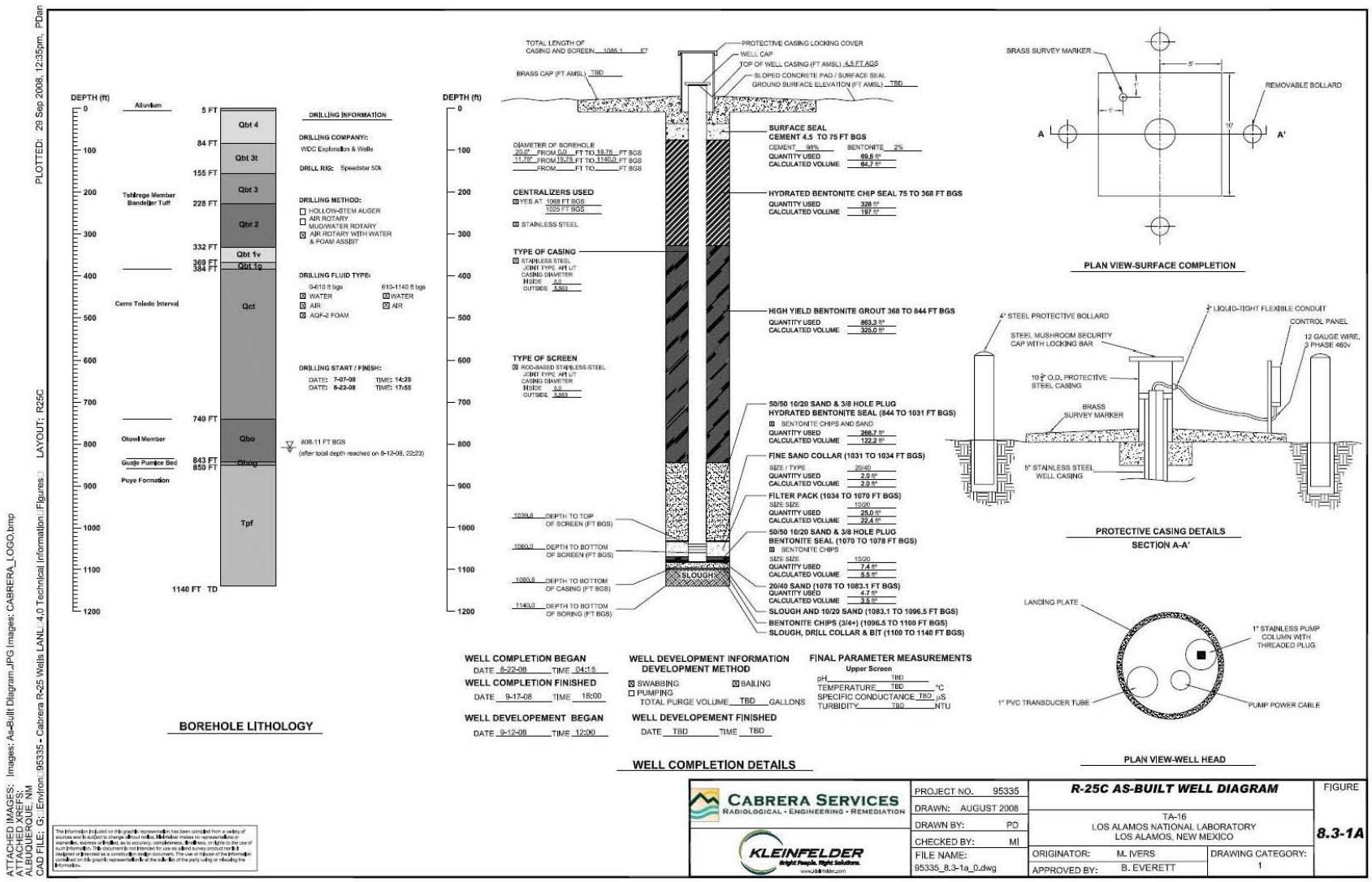

Figure 8.3-1 R-25c as-built well diagram

TECHNICAL NOTES FOR FIGURE 8.3-1: [1]

Survey Information[2]

Brass Marker

Northing: TBD

Easting: TBD

Elevation: TBD

Well Casing (top of stainless steel)

Northing: TBD

Easting: TBD

Elevation: TBD

BOREHOLE GEOPHYSICAL LOGS

Natural Gamma Ray, Induction, Neutron (Elemental Capture Sonde (ECS) and Accelerator Porosity Sonde (APS)), Gamma-Gamma Density (Triple Lithodensity (TLD))

DRILLING INFORMATION

Drilling Company

WDC Exploration and Wells

Drill Rig

Failing Co. SpeedStar 50K

Drill Methods

Air Rotary with Water and Foam Assist

Drilling Fluids

0-610 ft Baroid ®, AQF-2 ® Foaming Agent, air, and potable water

610-1140 ft air and potable water

MILESTONE DATES

Drilling

Start: 07/07/2008

Finished: 08/22/2008

Well Completion

Start: 08/22/2008

Finished: 09/17/2008

WELL DEVELOPMENT/AQUIFER EVALUATION

Development Methods

Performed swabbing, bailing, - formation not productive

Total Volume Purged (during completion): 732391 gal

Parameter Measurements (Final)

pH: TBD

Temperature: TBD

Specific Conductance: TBD

Turbidity: TBD

NOTES

(1) Additional information available in "Final Completion Report, Characterization Wells R-25c, Los Alamos National Laboratory, Los Alamos, New Mexico, September 2008.

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

TBD = Information will be provided in the addendum to the well construction report after activities are complete.

Table 3.0-1
Fluid Quantities Used During Drilling and Well Construction

Borehole	Date	Water (gal.)	Cumulative Water (gal.)	Foam (gal.)	Cumulative Foam (gal.)	Cumulative Returns in Pit: Fluids (gal.)
Drilling						
R-25c	07/01/08	500	500	0	0	-
	07/07/08	1800	2300	0	0	-
	07/10/08	1800	4100	50	50	-
	07/11/08	2800	6900	30	80	-
	07/16/08	2000	8900	0	80	-
	07/24/08	2000	10900	0	80	-
	07/25/08	3000	13900	35	115	-
	08/09/08	1500	15400	0	115	-
	08/10/08	500	15900	0	115	-
	08/20/08	500	16400	0	115	50,494
Well Construction						
R-25c	8/23/2008	300	300	n/a	n/a	n/a
	8/23/2008	400	700	n/a	n/a	n/a
	8/24/2008	3500	4200	n/a	n/a	n/a
	8/24/2008	600	4800	n/a	n/a	n/a
	8/24/2008	400	5200	n/a	n/a	n/a
	8/24/2008	200	5400	n/a	n/a	n/a
	8/24/2008	500	5900	n/a	n/a	n/a
	8/24/2008	500	6400	n/a	n/a	n/a
	8/24/2008	700	7100	n/a	n/a	n/a
	8/24/2008	1000	8100	n/a	n/a	n/a
	8/24/2008	900	9000	n/a	n/a	n/a
	8/24/2008	1300	10300	n/a	n/a	n/a
	8/25/2008	2500	12800	n/a	n/a	n/a
	8/25/2008	1200	14000	n/a	n/a	n/a
	8/25/2008	1200	15200	n/a	n/a	n/a
	8/25/2008	1000	16200	n/a	n/a	n/a
	8/25/2008	2500	18700	n/a	n/a	n/a
	8/25/2008	2500	21200	n/a	n/a	n/a
	8/25/2008	2500	23700	n/a	n/a	n/a
	8/25/2008	1300	25000	n/a	n/a	n/a
	8/26/2008	1200	26200	n/a	n/a	n/a
	8/26/2008	1000	27200	n/a	n/a	n/a
	8/26/2008	500	27700	n/a	n/a	n/a
	8/26/2008	2500	30200	n/a	n/a	n/a

Table 3.0-1 (continued)

Borehole	Date	Water (gal.)	Cumulative Water (gal.)	Foam (gal.)	Cumulative Foam (gal.)	Cumulative Returns in Pit: Fluids (gal.)
Well Construction (continued)						
R-25c	8/26/2008	200	30400	n/a	n/a	n/a
	8/26/2008	400	30800	n/a	n/a	n/a
	8/26/2008	400	31200	n/a	n/a	n/a
	8/26/2008	470	31670	n/a	n/a	n/a
	8/26/2008	539	32209	n/a	n/a	n/a
	8/26/2008	4000	36209	n/a	n/a	n/a
	8/26/2008	1196	37405	n/a	n/a	n/a
	9/15/2008	325	37730	n/a	n/a	n/a
	9/15/2008	325	38055	n/a	n/a	n/a
	9/15/2008	217	38272	n/a	n/a	n/a
	9/15/2008	217	38489	n/a	n/a	n/a
	9/15/2008	217	38706	n/a	n/a	n/a
	9/15/2008	217	38923	n/a	n/a	n/a
	9/15/2008	217	39140	n/a	n/a	n/a
	9/15/2008	217	39357	n/a	n/a	n/a
	9/15/2008	25	39382	n/a	n/a	n/a
	9/17/2008	73	39455	n/a	n/a	n/a
	9/17/2008	84	39539	n/a	n/a	n/a
	9/17/2008	84	39623	n/a	n/a	n/a
	9/17/2008	85	39708	n/a	n/a	n/a
	9/17/2008	100	39808	n/a	n/a	n/a
	9/17/2008	100	39908	n/a	n/a	n/a
Total (gal.)			39965		115	50,494
Total Volume R-25c (gal.)		**90,574**				

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

Table 6.0-1
R-25c Video and Geophysical Logging Runs

Date	Depth (ft)	Description
07/12/08	0 – 609.2	LANL video, natural gamma ray, and induction surveys run through open hole. Less than one (1) foot of water (likely fluids introduced during drilling) was observed in bottom of the borehole.
08/13/08	850 - 700	Schlumberger hostile natural gamma ray (HNGS) survey run up hole in cased borehole (16-inch steel casing from surface to 19.8 ft bgs; 11.75-inch steel casing from surface to 848.5 ft bgs).
08/13/08	850 - 700	Schlumberger elemental capture spectroscopy (ECS) survey run up hole in cased hole (16-inch steel casing from surface to 19.8 ft bgs; 11.75-inch steel casing from surface to 848.5 ft bgs). Poor quality log because instrument would not sit on casing wall. A bow spring centralizer was installed on the instrument and the hole was successfully ECS logged.
08/13/08	0 - 910	LANL video survey conducted to locate lost drill bit/ collar. Protruding rock ledge stopped advance of tool at 910 ft bgs. Uncased hole from 848.5 to 1140 ft bgs. Groundwater observed in borehole at 784 ft bgs.
08/14/08	0 - 933	LANL video survey conducted to view borehole redrilled to 1100 ft bgs. Obstruction (cobble ledge) stopped advance of tool at 933 ft bgs. Uncased hole from 848.5 to 1140 ft bgs. Groundwater observed in borehole at 808 ft bgs.
08/14/08	850 - 600	Schlumberger triple lithodensity detector (TLD) survey run up hole in cased hole (16-inch steel casing from surface to 19.8 ft bgs; 11.75-inch steel casing from surface to 848.5 ft bgs; open hole (10-inch diameter) from 848.5 to 1140 ft bgs).
08/14/08	850 - 600	Schlumberger accelerator porosity sonde (APS) survey run up hole in cased hole (16-inch steel casing from surface to 19.8 ft bgs; 11.75-inch steel casing from surface to 848.5 ft bgs; open hole (10-inch diameter) from 848.5 to 1140 ft bgs).
08/14/08	0 – 901	LANL video survey conducted in an attempt to bypass rock at 933 ft bgs but another cobble obstructed advance of tool at 901 ft bgs. Uncased hole from 848.5 to 1140 ft bgs. Groundwater observed in borehole at 808 ft bgs.
09/11/08	0 – 1085	LANL conducted a video survey of the interior of the well casing. The video survey indicated the top of the well screen was located 1040.1 ft bgs and the water level was 1058.3 ft bgs, just 2.2 feet above the bottom of the well screen. At this time the well screen was in good condition and free of any apparent obstructions.
09/11/08	1000 - 1085	LANL conducted a natural gamma ray and video survey of the interior of the well casing. Bentonite-grout was observed infiltrating the upper 12-13 feet of the well screen.

Table 7.2-1
Annular Fill Materials

Material	Volume in R-25c
Surface seal: cement slurry	69.6 ft^3
Bentonite seal: bentonite chips	328 ft^3
Bentonite seal: high solids bentonite grout	863.6 ft^3
Upper annular seal: bentonite chips	268.7 ft^3
Fine sand collar: 20/40 silica sand	2 ft^3
Primary filter: 10/20 silica sand	25 ft^3
Lower annular seal: bentonite chips	7.4 ft^3
Backfill material: 10/20 silica sand and bentonite chips	4.7 ft^3
Potable water	39, 965 gallons

Table 8.5-1
R-25c Geodetic Survey Data

Northing	Easting	Elevation	Identification
TBD	TBD	TBD	Brass Cap Embedded in Pad
TBD	TBD	TBD	Top of Protective Casing
TBD	TBD	TBD	Top of Well Cap

Appendix A

Lithologic Logs

Los Alamos National Laboratory
Regional Hydrogeologic Characterization Project
Borehole Lithologic Log

BOREHOLE ID: R-25c	**TECHNICAL AREA (TA):** 16	**PAGES: 5**
DRILLING COMPANY: WDC	**START DATE/TIME:** 07/07/08:1425	**END DATE/TIME:** 08/22/08:1755
DRILLING METHOD: Air Rotary	**MACHINE:** Failing Co. SpeedStar 50K	**SAMPLING METHOD:** Drill Cuttings
GROUND ELEVATION: **** ft above mean sea level (amsl)	**TOTAL DEPTH (TD):** 1140 ft below ground surface (bgs)	
DRILLERS: J. Leon/S. Huston	**LOGGERS:** M. Ivers/M. Pitterle	

DEPTH (ft)	LITHOLOGY	LITHOLOGIC SYMBOL	Notes
0 – 5	**ALLUVIUM:** Predominantly silt and fine sand (SM), with <5% medium to coarse sand, brown (5YR 4/4). Dry.	-	**Alluvium:** (0 – 5 ft bgs) Cuttings are very dirty; was not possible to distinguish individual components.
5 – 35	**TSHIREGE MEMBER, BANDELIER TUFF:** Pale yellowish brown (10YR 6/2), non to partially welded, devitrified ash-flow tuff. WR: Fine ash matrix with sparse crystals of quartz and sanidine, <1mm, rare pumice, and rare dark, volcanic lithics of intermediate composition. +35F: Predominantly crystals, <1mm in size. Dry.	Qbt 4	**Qbt 4 Tshirege Member of Bandelier Tuff:** (5 – 84 ft bgs) Samples from 20-50' are contaminated with bentonite pellets used to set seal at the bottom of the surface casing prior to grouting.
35 – 55	**35 to 55 ft bgs:** Light brownish gray (5YR 6/1) to light gray (10YR 7/1), nonwelded to moderately welded, devitrified ash-flow tuff. WR: Sparse crystals of sanidine and quartz, rare pumice, lithics not observed (cuttings are coated with dust). +35F: Predominantly crystals, 1mm or less. Dry.		
55 – 84	**55 – 84 ft bgs:** Pale yellowish brown (10YR 6/2) to medium gray (N5), non to partially welded, devitrified ash-flow tuff. WR: Fine ash matrix with abundant felsic crystals of sanidine and quartz, mostly 2-3mm, up to 5mm at the base of the interval, common white pumice, and minor volcanic lithics of intermediate composition up to 2cm. +35F: Predominantly crystals. Wet. 55 – 60 ft bgs: predominantly crystals, up to 2mm. Many appear rounded.		

BOREHOLE ID: R-25c	**TECHNICAL AREA (TA):** 16	**PAGES: 5**	
84 – 105	**TSHIREGE MEMBER, BANDELIER TUFF:** Brown (5YR 4/4), nonwelded, devitrified ash-flow tuff. WR: Matrix of fine ash (95%) with minor crystals of sanidine and quartz, minor dark volcanic lithics of intermediate composition, mostly <3mm, and rare pumice. +10F: Rounded tuff clasts (matrix) with minor crystals. +35F: 95% crystals, 5% tuff clasts and lithics. Dry to wet.	Qbt 3t	**Qbt 3t Tshirege Member of Bandelier Tuff:** (84 – 155 ft bgs)
105 – 145	**105 – 145 ft bgs:** Pale yellowish brown (10YR 6/2), nonwelded, devitrified ash-flow tuff. WR: Matrix of fine ash (80-90%), abundant crystals of sanidine, quartz and feldspar, rare pumice, minor volcanic lithics of crystal rich tuff of intermediate composition. +10F: Predominantly lithics up to 12mm. +35F: Roughly equal proportions of lithics and crystals. Dry.		
145 – 155	**145 – 155 ft bgs:** Brownish black (5YR 2/1) to medium gray (N5), moderately welded, devitrified ash-flow tuff. WR: Ash matrix with abundant (18-20%) crystals of sanidine and quartz, 2-3mm, rare pumice, very light gray (N8) to white, minor light brown (5YR 5/6) and reddish brown volcanic lithics. +10F: Tuff matrix clasts. +35F: Predominantly crystals, with lesser tuff clasts and lithics. Wet.		
155 – 215	TSHIREGE MEMBER, BANDELIER TUFF: Nonwelded, devitrified, ash-flow tuff. WR: Predominantly crystals, light gray (N8) tuff clasts, lithics and rare pumice. +10F: Tuff clasts and lithics. +35F: 95% crystals.	Qbt 3	**Qbt 3 Tshirege Member of Bandelier Tuff:** (155 – 228 ft bgs)
215 – 225	**215 – 225 ft bgs:** No Recovery		
225 – 228	**225 – 228 ft bgs:** Nonwelded, devitrified, ash-flow tuff. WR: Predominantly crystals, light gray (N8) tuff clasts, lithics and rare pumice. +10F: Tuff clasts and lithics. +35F: 95% crystals. **Note:** Poorly recovered. An increase in the penetration rate indicates soft formation, possibly the white, nonwelded tuff at the base of Qbt 3.		Poorly recovered. An increase in the penetration rate indicates soft formation, possibly the white, nonwelded tuff at the base of Qbt 3.

BOREHOLE ID: R-25c	**TECHNICAL AREA (TA):** 16	**PAGES: 5**	
228 – 240	TSHIREGE MEMBER, BANDELIER TUFF: Grayish red (10R 4/2), moderately to strongly welded, devitrified ash-flow tuff. WR: Recovered >75% crystals of sanidine and quartz, lesser tuff clasts, lithics and rare pumice. +35F: 90-95% crystals.	Qbt 2	**Qbt 2 Tshirege Member of Bandelier Tuff:** (228 – 332 ft bgs) **Note:** The very low penetration rate through the interval suggests a moderately to strongly welded tuff; however, the lack of recovery of tuff (matrix) may indicate a nonwelded tuff.
240 – 305	**240 – 305 ft bgs:** Grayish brown (5YR 3/2), partially to moderately welded, devitrified ash-flow tuff. WR: Tuff matrix is crystal rich, 20%+ sanidine and quartz, light gray (N8) to white, vapor-phase altered pumice are common, minor dark, volcanic lithics. +10F: Tuff clasts (matrix) with minor lithics. +35F: 80-90% crystals with lesser tuff clasts and minor lithics. **270 – 280 ft bgs:** Matrix is yellowish brown (10YR 6/2), non to partially welded (very poor recovery of matrix).		
305 – 332	**305 – 332 ft bgs:** Grayish brown (5YR 3/2), moderately welded, devitrified ash-flow tuff. WR: Tuff matrix is crystal rich, 20%+ sanidine and quartz, minor light gray (N8) to white, vapor-phase altered pumice, rare dark, volcanic lithics. +10F: Tuff clasts (matrix) with minor lithics. +35F: 80-90% crystals with lesser tuff clasts and minor lithics.		
332 – 355	**TSHIREGE MEMBER, BANDELIER TUFF:** Grayish brown (5YR 3/2) to dusky brown (5YR 2/2), non to partially welded, devitrified ash-flow tuff. WR: Tuff matrix is crystal rich (+30%). Vapor-phase alteration of the matrix is not readily apparent in the cuttings, although the color is lighter. Minor vapor-phase altered pumice (sugary texture), and rare dark volcanic lithics. +10F: Tuff clasts (matrix) with minor lithics. +35F: 80-90% crystals with lesser tuff clasts and minor lithics.	Qbt 1v	**Qbt 1v Tshirege Member of Bandelier Tuff:** (332 – 369 ft bgs)
355 – 369	**355 – 369 ft bgs:** Very poor recovery of the matrix (recovered mostly crystals) indicates the tuff may be nonwelded, or could to vapor-phase alteration of the matrix.		
369 – 384	**TSHIREGE MEMBER, BANDELIER TUFF:** Medium gray (N5), non welded, devitrified ash-flow tuff. WR: Recovery consists predominantly of crystals of sanidine and quartz, and abundant dark gray to reddish brown volcanic lithics of intermediate compositions, up to 16mm. Pinkish gray, vitric pumice with fibrous textures are common. +10F: Predominantly lithics. +35F: Predominantly crystals with minor lithics and tuff matrix. **380 – 382 ft bgs:** Increase in vitric pumice, pale yellowish brown (10YR 6/2) to grayish orange pink (5YR 7/2), up to 1cm, and a higher concentration of volcanic lithics.	Qbt 1g	**Qbt 1g Tshirege Member of Bandelier Tuff:** (369 – 384 ft bgs)

BOREHOLE ID: R-25c	**TECHNICAL AREA (TA):** 16	**PAGES: 5**	
384 – 385	**CERRO TOLEDO INTERVAL:** Volcaniclastic sediments. WR: Poorly sorted, fine to coarse sand and fine gravel size clasts, predominantly angular to subangular, locally subrounded (especially pumice and nonwelded tephras). Clasts are predominantly volcanic tuffs and lavas of rhyolitic to intermediate compositions, pumice (mostly vitric), nonwelded tephras, abundant felsic crystal fragments (noted bipyramidal quartz), and rare siltstones. Clasts are generally light to dark gray (N8-4) and reddish brown. Pumice and tephras are light brown to white and orange where altered (oxidized).		**Cerro Toledo Interval:** (384 – 740 ft bgs)
385 – 395	**385 – 395 ft bgs:** No Recovery		
395 – 500	**415 – 430 ft bgs:** Decrease in pumice, less orange coloration (oxidation); pumice are generally white. **430 – 435 ft bgs:** No recovery **440 – 445 ft bgs:** Interval contains approximately 75% white to slightly orange, vitric pumice.	Qct	
500 – 520	**500 – 515 ft bgs:** Crystal rich tephra (very poor recovery of the tuff matrix). WR: White to light gray and grayish pink, moderately indurated ash. +10F: Tephra clasts. +35F: +95% felsic crystal fragments. **515 – 520 ft bgs:** No Recovery		
520 – 591	**520 – 591 ft bgs:** Volcaniclastic sediments. Same as above, with an increase in mafic volcanics, very dark gray (N3) to black (N2.5), andesites, dacites, and rare volcanic siltstones. **530 – 535 ft bgs:** No Recovery		
591 – 610	**591 – 616 ft bgs:** Brown (10YR 5/3) to dark yellow (10YR 3/4) (wet), nonwelded, devitrified ash-flow tuff. WR: Ash matrix with rare light gray (N7-8) to dark yellowish orange (10YR 6/6), vitric pumice, common felsic crystals, sparse dark volcanic lithics of intermediate composition. +10F: Predominantly tuff matrix (rounded clasts) with minor lithics. +35F: Tuff clasts, pumice, minor lithics and crystals.	Qct	
610 – 640	**610 – 640 ft bgs:** No Recovery		
640 – 650	**640 – 650 ft bgs:** Very light gray (N9) to dark yellow orange (10 YR 6/6) med. – coarse sand size pumice fragments, subround, trace clear phenocrysts.		
650 – 690	**650 – 690 ft bgs:** No Recovery		

BOREHOLE ID: R-25c	**TECHNICAL AREA (TA):** 16	**PAGES: 5**	
690 – 740	**690 – 740 ft bgs:** Yellowish orange (10YR 6/4) (check color), nonwelded, vitric ash-flow tuff. WR: Fine ash matrix with common pumice, vitric, vesicular/frothy textures, white (N9) to light gray (10YR 7/2) and yellowish orange (10YR 6/4), common sanidine and quartz, minor volcanic lithics of intermediate compositions, dark gray to very dark gray (N5-3) and yellowish red (5YR 4/4). Pumice have very fine mafic crystals. +10F: Vitric pumice and lesser tuff clasts, and minor lithics. +35F: Predominantly crystals with roughly equal parts of tuff matrix and pumice, and common lithics.		
740 – 843	**OTOWI MEMBER, BANDELIER TUFF:** White, partially welded, vitric ash-flow tuff. WR: Fine ash with abundant vitric pumice, white (N9), porous, vesicular textures (difficult to distinguish between tuff matrix and pumice in cuttings), minor to common sanidine and quartz, common dark volcanic lithics of intermediate compositions. +10F: Predominantly pumice with lesser tuff matrix clasts, and common lithics. +35F: Generally equal parts pumice/tuff clasts, crystals and lithics.		
843 – 850	**GUAJE PUMICE BED:** Cannot be readily distinguished from the Otowi in cuttings. However, a marked increase in larger, rounded pumice in the +10F from 840-845' may represent the top of the Guaje Pumice Bed. Otherwise the interval is the same as the Otowi Member above.	Qbog	**Guaje Pumice Bed:** (843 – 850 ft bgs)
850 –1045	**PUYE FORMATION:** Volcaniclastic sediments. WR: Poorly sorted, medium to coarse sand and fine gravel size clasts (up to 3.5cm) of angular to subangular, and rarely subrounded volcanic flows and tuffs of intermediate composition. Clasts range from very light gray (N8) to dark gray (N4), with lesser dusky red (2.5YR 3-4/4), light brown (7.5YR 6/4) and light gray (5YR 7/1). Tuffs and rhyolite flows are generally lighter in color, are partially to densely welded, often crystal rich, and occasionally vitric. +35F: Generally the same as WR, but includes minor amounts of felsic crystal fragments, <5%.	Tpf	**Puye Formation:** (850 – 1140 ft bgs) **Note:** Sample recovery through the interval was very poor. Due to the large volumes air needed to drill, and the large quantities of water produced from the formation, it was not possible to recover the fines, and sample quality is poor.
1045-1140	**1045 – 1140 ft bgs:** Volcaniclastic sediments, as above. Noted an increase in darker intermediate volcanic clasts, and a decrease in clast size; fine gravel is rare to absent. Felsic crystal fragments are rare to absent.		

Appendix B

Geophysical Logs
(on DVD included with this document)

Appendix C

Downhole Video Logs
(on DVD included with this document)