ESHID-601079

DRAFT
COMPLETION REPORT
INTERMEDIATE WELL I-1
LOS ALAMOS NATIONAL LABORATORY
LOS ALAMOS, NEW MEXICO
PROJECT NO. 49436

Prepared for:

The US Department of Energy and the
National Nuclear Security Administration through the
US Army Corps of Engineers
Sacramento District

Prepared by:

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A Corehole Video Log
B Lithologic Log

LIST OF ACRONYMS AND ABBREVIATIONS

bgs	below ground surface
DOE	US Department of Energy
DTH	down the hole
DTW	depth to water
ft	foot/feet
in.	inch
Kleinfelder	Kleinfelder, Inc.
LANL	Los Alamos National Laboratory
NMED	New Mexico Environment Department
OD	outside diameter
SOP	standard operating procedure
Spectrum	Spectrum Exploration, Inc.
TA	Technical Area
TD	total depth

ABSTRACT

Intermediate well I-1 was installed as part of the Risk Reduction and Environmental Stewardship-Remediation Services project at Los Alamos National Laboratory in accordance with the "Mortandad Canyon Groundwater Work Plan, Revision 1" (LANL, 2004) and the "Final Drill Plan for Intermediate Wells, Mortandad Canyon" (Kleinfelder, 2004). The US Department of Energy, with technical assistance from Los Alamos National Laboratory, contracted and directed the installation of this well.

Data from I-1 will be used in conjunction with data from other wells in Mortandad Canyon to improve the conceptual model of the geology, hydrogeology, and hydrochemistry of the area to provide data for numerical models that address contaminant migration in the vadose (unsaturated) zone. This information will be used to facilitate decision-making with regard to regulatory compliance, risk assessment, and remediation.

The majority of the fieldwork for I-1 was conducted from November 23, 2004, to January 9, 2005. Core was collected from 75 to 843.2 feet (ft) below ground surface (bgs). The stratigraphic units that were encountered during drilling include (in descending order) Tshirege member of the Bandelier tuff, Tsankawi Pumice bed, Cerro Toledo interval, Otowi member of the Bandelier tuff, Guaje pumice bed, Puye formation, Cerros del Rio basalt, and Puye fanglomerate.

Geophysical logging was performed in the open I-1 corehole to help delineate the hydrostratigraphy and to facilitate well design. A well was installed with a single-screened interval from 815.5 to 825.5 ft bgs within a fanglomerate unit of the Puye Formation. The total depth of the well is 825.6 ft bgs. No water has been detected in the well.

1.0 INTRODUCTION

This completion report summarizes the site preparation, coring, well installation, and related activities for intermediate well I-1. Kleinfelder, Inc. (Kleinfelder), under contract to the US Army Corps of Engineers, was responsible for coring, installing, testing, and sampling activities. The US Department of Energy (DOE) funded and directed this work.

Intermediate well I-1 is located in Technical Area (TA) 35 of the Los Alamos National Laboratory (LANL) in Mortandad Canyon, approximately 0.25 miles east of the TA-50 outfall (Figure 1.0-1). It was installed to determine if contaminant releases have affected the quality of intermediate perched groundwater between the TA-50 outfall and Test Well 8. Data quality objectives for this and other intermediate wells are provided in the "Mortandad Canyon Groundwater Work Plan" (LANL, 2004) and the "Final Drilling Plan for Intermediate Wells, Mortandad Canyon" (Kleinfelder, 2004). Water quality, geochemical data, aquifer characteristics, and geologic information obtained from I-1 will augment the conceptual model and knowledge of contaminant distribution in the intermediate perched zone of the Mortandad Canyon system.

The objectives of the drilling activities were to collect core from the encountered geologic formations, collect groundwater samples from perched intermediate groundwater (if present), and install a single-screened monitoring well in the Guaje pumice bed or basalt flows. The projected total depth (TD) of the corehole was 800 feet (ft) below ground surface (bgs); the actual TD of the I-1 corehole was 843.2 ft bgs.

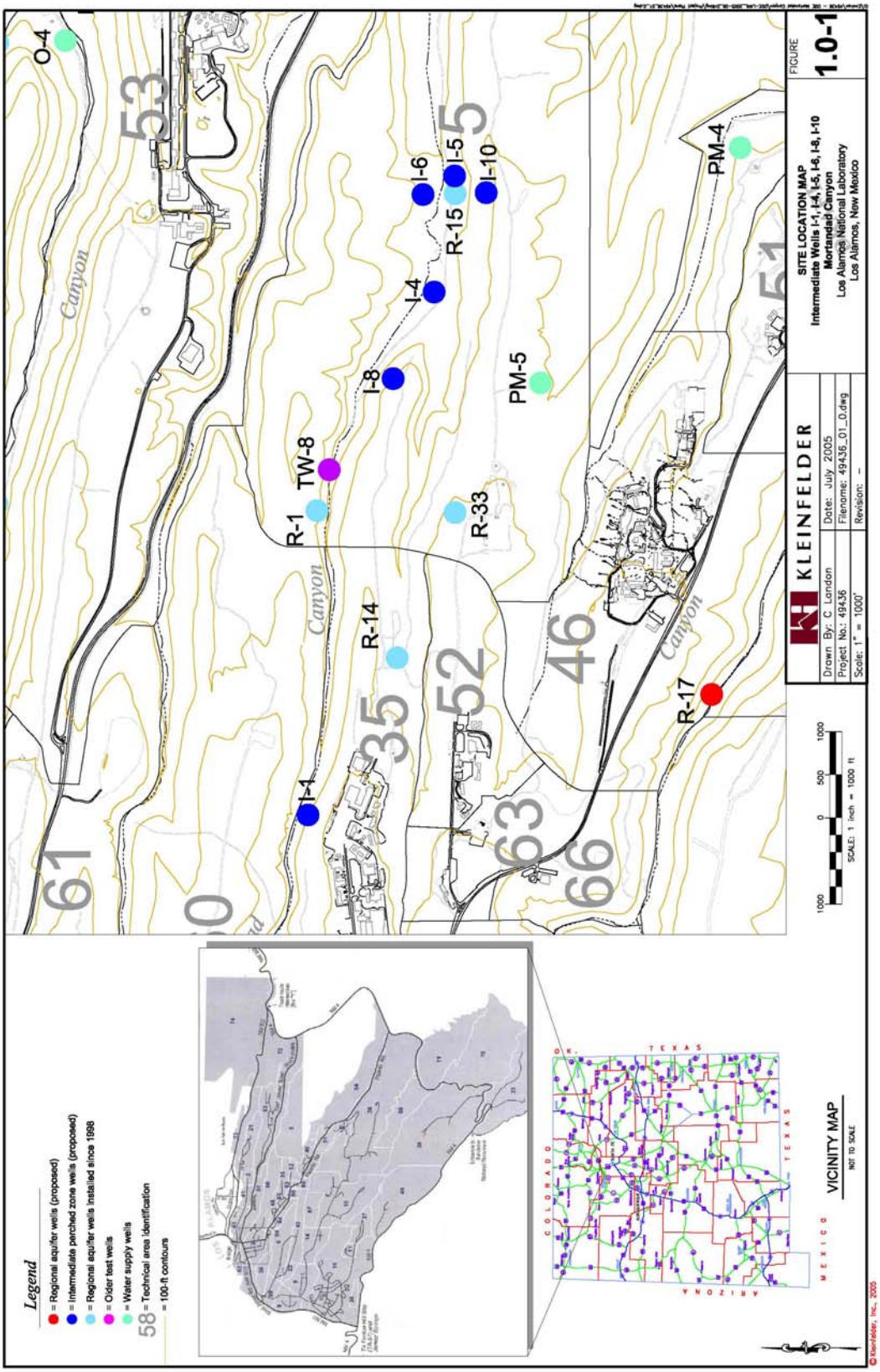
The information presented in this report was compiled from field reports and activity summaries generated by Kleinfelder, LANL, and subcontractor personnel. Original records, including field reports, field logs, and survey records, are on file in Kleinfelder's Albuquerque office and LANL's Record Processing Facility. Detailed analysis and interpretation of hydrogeologic data will be included in separate technical documents to be prepared by LANL.

2.0 DRILLING ACTIVITIES

Drilling activities occurred from November 23 to December 18, 2004, generally in one 12-hour shift per day, seven days per week, by the drill crew and two site geologists. Spectrum Exploration, Inc. (Spectrum), advanced the I-1 corehole to a depth of 843.2 ft bgs to characterize contaminant profiles in the vadose zone and to investigate for perched water zones.

Spectrum used a Delta Base DB540 equipped with HQ_3 Coring, Geobarrel, and 115-millimeter Tubex drilling systems, air compressors, and support equipment to conduct the coring. The upper 75 ft of the corehole were drilled using a 7⅝-inch (in.) Tubex down-the-hole (DTH) hammer system. I-1 was cored and drilled using air-rotary drilling techniques. Drilling fluids were not introduced into the corehole.

On November 23, Spectrum mobilized drilling equipment to the site and began drilling using a 7⅜-inch (in.) Tubex® DTH hammer system. Temporary 6⅝-in.-outside diameter (OD) Tubex® casing was installed to a TD of 75 ft bgs. Coring was not performed within the upper 75 ft of ground surface (with approval from LANL) in order to begin core collection at approximately the same elevation as the bottom of Mortandad Canyon.


Legend
= Regional aquifer wells (proposed)
= Intermediate perched zone wells (proposed)
= Regional aquifer wells installed since 1998
= Older test wells
= Water supply wells
58 = Technical area identification
= 100-ft contours
VICINITY MAP
NOT TO SCALE
SCALE: 1 inch = 1000 ft
KLEINFELDER
Drawn By: C Landon
Project No.: 49436
Scale: 1" = 1000'
Date: July 2005
Filename: 49436_01_0.dwg
Revision: –
SITE LOCATION MAP
Intermediate Wells I-1, I-4, I-5, I-6, I-8, I-10
Mortandad Canyon
Los Alamos National Laboratory
Los Alamos, New Mexico
FIGURE
1.0-1
O-4
I-1
I-4
I-5
I-6
I-8
I-10
R-1
R-14
R-15
R-17
R-33
TW-8
PM-4
PM-5
Canyon
53
61
35
52
63
66
46
51
5

On November 24, a 4⅜-in. Geobarrrel core bit was used to advance the corehole to 132.5 ft bgs. Fourteen runs of core were collected with recovery varying from 0 to 100%. Inspection of the core revealed a wet zone at 127.5 ft bgs. Drill crews went on days off.

On November 29, drill crews returned from days off. Spectrum advanced the corehole from 127.5 to 152.5 ft bgs. Indications of groundwater were not observed in the corehole.

On November 30, Spectrum advanced the corehole from 152.5 to 225 ft bgs. Air circulation was lost, and efforts to further advance 6⅝-in.-OD Tubex® casing began.

On December 1, the Tubex® casing was advanced to 225 ft bgs.

On December 2, Spectrum advanced the corehole from 225 to 232.5 ft bgs. Air circulation was lost, and efforts to telescope the 5½-in.-OD Tubex® casing inside of the 6⅝-in. Tubex® casing began.

On December 3, the corehole was advanced to 260 ft bgs, and 5½-in.-OD Tubex® casing was installed from 59 to 260 ft bgs using a 6-in. under-reamer bit. Coring resumed later that day.

On December 4, coring continued. At 512.5 ft bgs, the drill bit could not be further advanced into the Cerros del Rio basalt.

On December 5, the drill string was tripped out of the hole to replace the bit. Coring resumed using a 3.895-in. HQ_3 core bit. The corehole was advanced to 536.3 ft bgs.

On December 6, the corehole was advanced from 536.3 to 575.6 ft bgs. Core barrel liners were not used below 550.6 ft bgs because of the difficulty retrieving samples from the core barrel.

On December 7, coring continued from 575.6 to 626.3 ft bgs. The core collected from the interval of 612.1 to 616.3 ft bgs was saturated; however, no standing water was detected in the corehole after waiting approximately 15 minutes. On December 8, coring continued from 626.3 to 680.8 ft bgs. The drill crews went on days off.

On December 15, drill crews returned from days off. No water was detected at a depth of 680.8 ft bgs upon return. Coring continued through December 18, when the corehole was advanced to a TD of 843.2 ft bgs. A Kleinfelder representative ran LANL-owned natural gamma and induction array geophysical tools down the corehole. Observations from the video log revealed that the lower section of the 5½-in. OD Tubex® casing had unthreaded at 83 ft bgs and had dropped approximately 60 ft. This casing was later retrieved.

On December 19, a bailer was used to attempt to sample any corehole fluids. The bailer came up dry on several attempts, and a water sample could not be obtained. On December 20, depth-to-water (DTW) measurements indicated that water had not accumulated in the corehole.

On January 6, 2005, DTW measurements indicated that the corehole was dry. The bottom of the corehole was measured at 828.5 ft bgs, indicating approximately 14.7 ft of slough. Kleinfelder

was instructed by DOE to construct a well in the corehole to monitor for the possible future presence of perched water.

From January 6 through January 9, a monitoring well with a single 10-ft section of well screen was installed from 815.5 to 825.5 ft bgs. Spectrum installed the annular fill materials for the well screen as the Tubex casings were removed. The drill rig was demobilized on January 11.

3.0 SAMPLING ACTIVITIES

Core, groundwater screening samples, and waste characterization samples were collected at I-1 in accordance with the drilling plan (Kleinfelder, 2004).

3.1 Core Sampling

Core was collected below 75 ft bgs using a 5-ft-long core barrel. Selected core was sampled to analyze for anions, cations, moisture content, tritium, radionuclides, and stable isotopes (Table 3.1-1). Analytical results will be included in a future investigation report prepared by LANL. The remaining core was placed in lay-flat plastic tubing, labeled, and stored in standard LANL Environmental Restoration core boxes, which were transported to the Field Support Facility for archiving and storage.

LANL Radiation Control Technicians screened the core prior to its removal from the drill site.

3.2 Groundwater Sampling

Groundwater was not observed in the corehole during drilling and did not accumulate in the well; thus, groundwater samples were not collected.

3.3 Waste Characterization Sampling

The investigation-derived waste consisted of drilling cuttings and was sampled. Drilling fluids were not used or produced at the drill site. Samples of the cuttings have been submitted to Hall Environment Analysis Laboratory in Albuquerque, NM, and are being analyzed for anions, polychlorinated biphenyls, volatiles, metals, perchlorate, and radionuclides. Analytical results are pending.

4.0 COREHOLE LOGGING

Kleinfelder ran video and geophysical logging equipment in the I-1 corehole prior to well installation (Table 4.0-1). These visual observations and geophysical data help characterize corehole conditions and hydrostratigraphy, facilitating project personnel in proper well design. The video log is attached as a DVD in Appendix A.

Table 3.1-1
Core Samples Collected and Analyzed

Core Samples Location ID MO-24233			ANALYSES						
Sample ID	Sample interval (ft)	Date/Time	moisture	tritium H3	anions/cations	N14N15	D2H O18O16	ARS (DOT screening)	Notes
CAMO-05-56912	75.8-77.5	11/24/2004 7:51	x	x	x	x	x	x	
CAMO-05-56913	86.1-87.8	11/24/2004 9:45	x	x	x	x		x	
CAMO-05-56914	95.8-97.4	11/24/2004 9:55	x	x	x	x		x	
CAMO-05-56915	102.5-103.8	11/24/2004 10:05	x	x	x	x		x	
CAMO-05-56916	115.5-117.1	11/24/2004 10:35	x	x	x	x		x	
CAMO-05-56917	129.3-127.5	11/24/2004 12:54	x	x	x	x	x	x	
CAMO-05-56918	134-135.5	11/29/2004 15:50	x	x	x	x		x	
CAMO-05-56919	144-145.5	11/29/2004 16:30	x	x	x	x		x	
CAMO-05-56920	153.5-155	11/30/2004 8:45	x		x	x		x	poor recovery, no N isotopes
CAMO-05-56921	163.5-165	11/30/2004 10:50	x	x	x	x		x	
CAMO-05-56922	174.5-176.5	11/30/2004 11:10	x	x	x	x	x	x	
CAMO-05-56923	262.5-263.7	12/3/2004 11:00	x	x	x	x		x	
CAMO-05-56924	272.5-273.3	12/3/2004 11:16	x	x	x	x	x	x	
CAMO-05-56925	324-326	12/3/2004 0:00	x	x	x	x	x	x	
CAMO-05-56926	372.5-374.5	12/3/2004 15:45	x	x	x	x	x	x	
CAMO-05-56927	423-425	12/4/2004 0:00	x	x	x	x	x	x	
CAMO-05-56928	473.4-475.4	12/4/2004 11:40	x	x	x	x	x	x	

Table 4.0-1
Corehole Logging

Operator	Date	Cased Footage (ft bgs)	Open-Hole Interval (ft bgs)	Remarks	Tools
Kleinfelder	12/18/04	0-322	322-838	Casing dropped to 322 ft bgs	Array induction, natural gamma
Kleinfelder	12/18/04	0-322	322-838	None	Video camera

4.1 Video Logging

Kleinfelder personnel video taped the corehole on December 18, 2004, to assess for evidence of perched groundwater (Table 4.0-1; Appendix A contains a DVD of the video log). Evidence of perched water was not observed in the corehole.

4.2 Geophysical Logging

On December 18, Kleinfelder used a Mount Sopris MGXII geophysical console to run LANL-owned array-induction and natural-gamma geophysical tools down the I-1 corehole. Natural gamma logging was used primarily to evaluate the geology and locate geologic contacts; array induction logging was used primarily to evaluate the presence of perched water. The natural gamma and array-induction (conductivity) logs are shown in Figure 4.2-1.

5.0 HYDROGEOLOGY

LANL's Earth and Environmental Sciences 6 staff provided preliminary interpretation of geologic contacts based on core. Groundwater occurrence is interpreted from drilling observations, open-hole video logging, geophysical logging, and water-level measurements.

5.1 Geology

Visual examination of core, open-hole video logs, and preliminary geophysical logs were used to determine the stratigraphy at I-1 (Figure 5.1-1). In descending order, the stratigraphic units encountered during drilling of the I-1 corehole are Tshirege member of the Bandelier tuff, Tsankawi pumice bed, Cerro Toledo interval, Otowi member of the Bandelier tuff, Guaje pumice bed, Puye formation, Cerros del Rio basalt, and Puye fanglomerate. The lithologic log is presented in Appendix B and provides detailed descriptions of the texture and composition of drill cuttings samples.

5.2 Groundwater Occurrence and Characteristics

Groundwater occurrences are interpreted from drilling observations, open-hole video logging, geophysical logging, and water-level measurements. Saturated or moist core was encountered from the interval of approximately 590 to 620 ft bgs; however, water did not accumulate in the corehole after 15 minutes. In addition, perched groundwater was not observed in the corehole video.

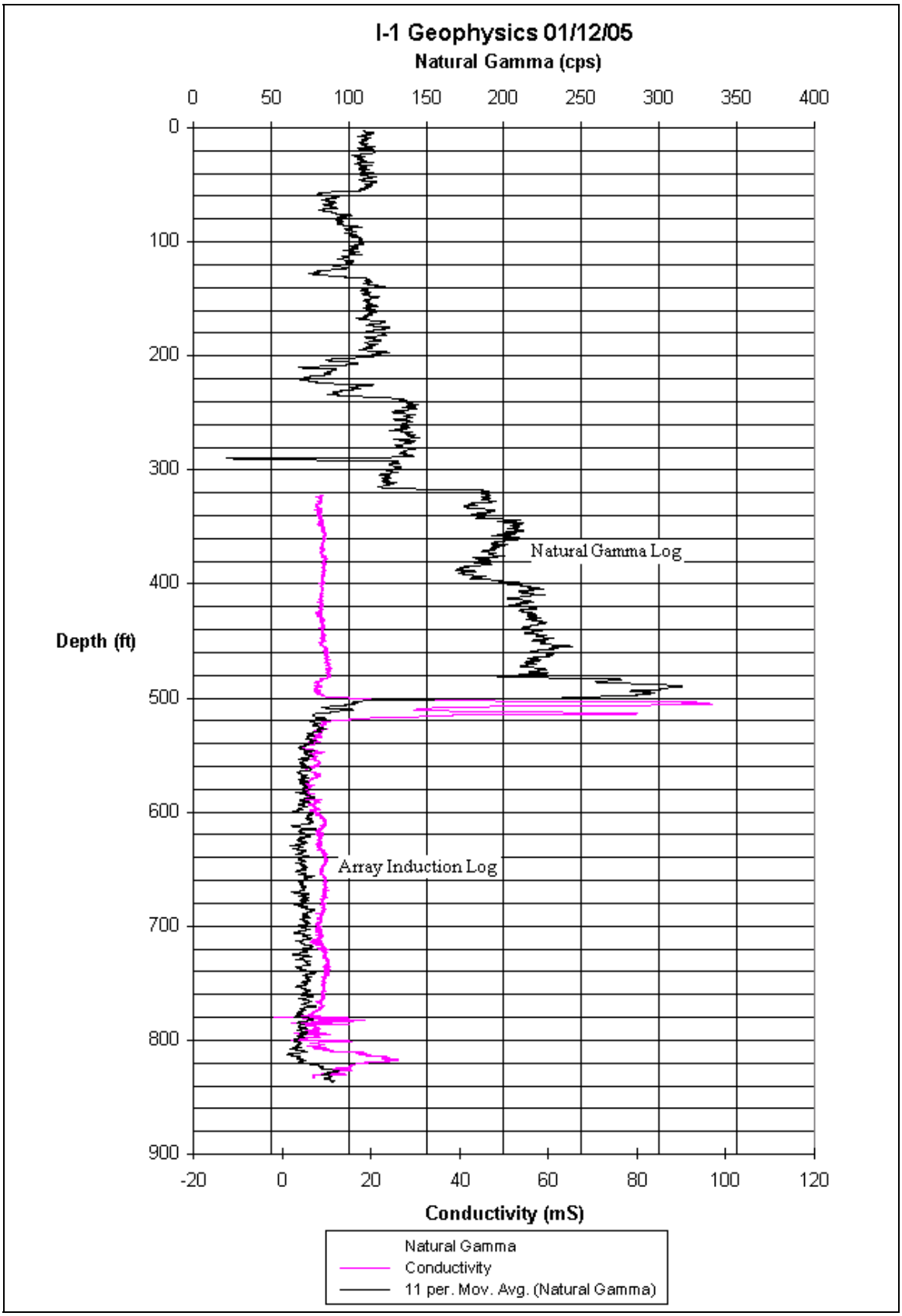
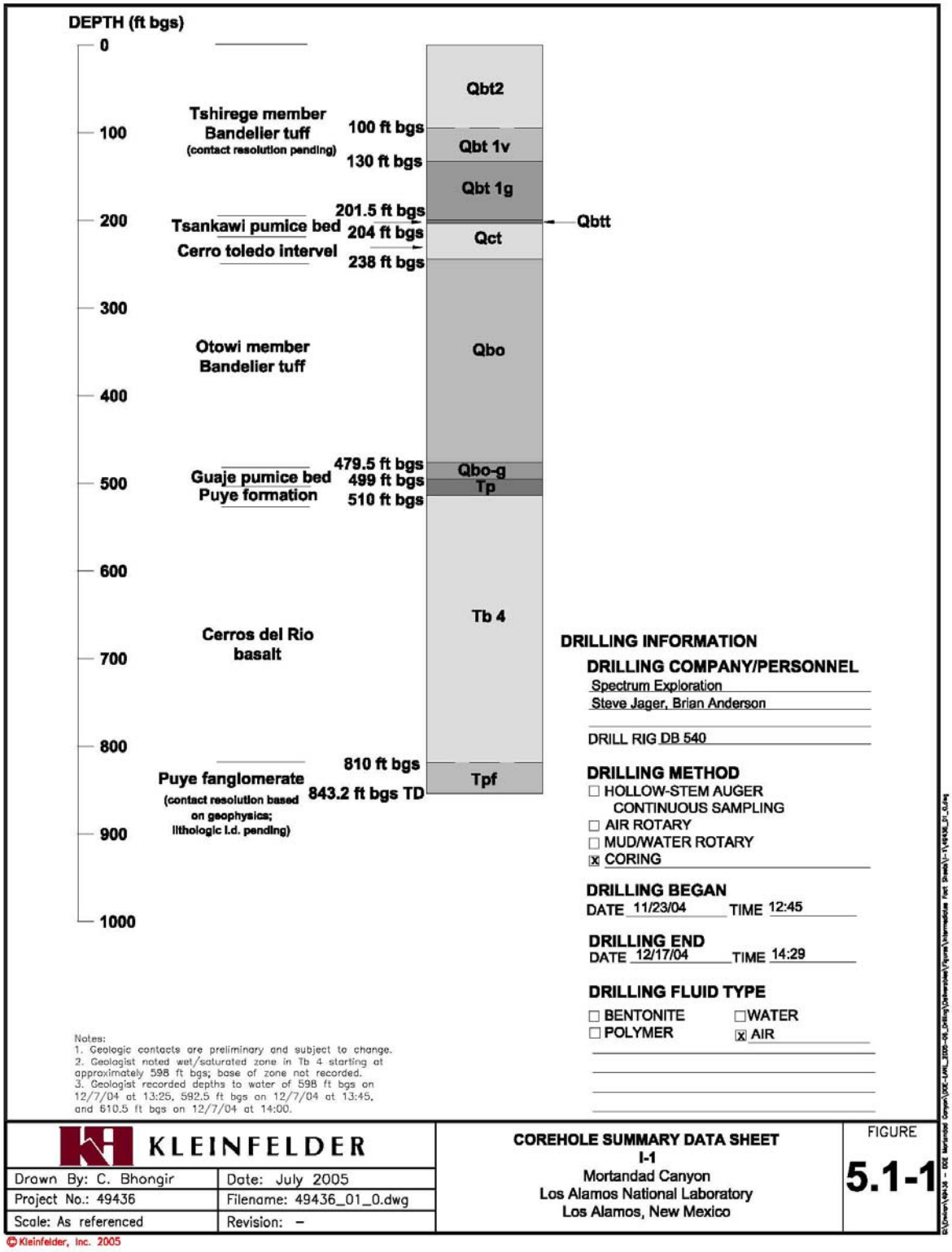


Figure 4.2-1. Natural Gamma and Induction Array Geophysical Logs


DEPTH (ft bgs)
0
100
200
300
400
500
600
700
800
900
1000
Tshirege member
Bandelier tuff
(contact resolution pending)
Tsankawi pumice bed
Cerro toledo intervel
Otowi member
Bandelier tuff
Guaje pumice bed
Puye formation
Cerros del Rio
basalt
Puye fanglomerate
(contact resolution based on geophysics; lithologic I.d. pending)
100 ft bgs
130 ft bgs
201.5 ft bgs
204 ft bgs
238 ft bgs
479.5 ft bgs
499 ft bgs
510 ft bgs
810 ft bgs
843.2 ft bgs TD
Qbt2
Qbt 1v
Qbt 1g
Qbtt
Qct
Qbo
Qbo-g
Tp
Tb 4
Tpf
DRILLING INFORMATION
DRILLING COMPANY/PERSONNEL
Spectrum Exploration
Steve Jager, Brian Anderson
DRILL RIG DB 540
DRILLING METHOD
☐ HOLLOW-STEM AUGER
CONTINUOUS SAMPLING
☐ AIR ROTARY
☐ MUD/WATER ROTARY
☒ CORING
DRILLING BEGAN
DATE 11/23/04 TIME 12:45
DRILLING END
DATE 12/17/04 TIME 14:29
DRILLING FLUID TYPE
☐ BENTONITE ☐ WATER
☐ POLYMER ☒ AIR
Notes:
1. Geologic contacts are preliminary and subject to change.
2. Geologist noted wet/saturated zone in Tb 4 starting at approximately 598 ft bgs; base of zone not recorded.
3. Geologist recorded depths to water of 598 ft bgs on 12/7/04 at 13:25, 592.5 ft bgs on 12/7/04 at 13:45, and 610.5 ft bgs on 12/7/04 at 14:00.
KLEINFELDER
Drawn By: C. Bhongir
Date: July 2005
Project No.: 49436
Filename: 49436_01_0.dwg
Scale: As referenced
Revision: –
COREHOLE SUMMARY DATA SHEET
I-1
Mortandad Canyon
Los Alamos National Laboratory
Los Alamos, New Mexico
FIGURE
5.1-1
© Kleinfelder, Inc. 2005

6.0 WELL DESIGN AND CONSTRUCTION

On January 6, 2005, Kleinfelder received well construction specifications after approval from DOE, LANL, and discussions with the New Mexico Environment Department (NMED). The well was constructed between January 6 and January 9, 2005.

6.1 Well Design

The Mortandad Canyon Groundwater Work Plan (LANL, 2004) called for a single-screened interval in the Guaje Pumice Bed, or basalt flows. Screened-interval placement was based on evaluation of geophysical data, core samples, and field observations.

6.2 Well Construction

Decontamination of the stainless-steel components was performed on site prior to well construction using a high-pressure hot water washer.

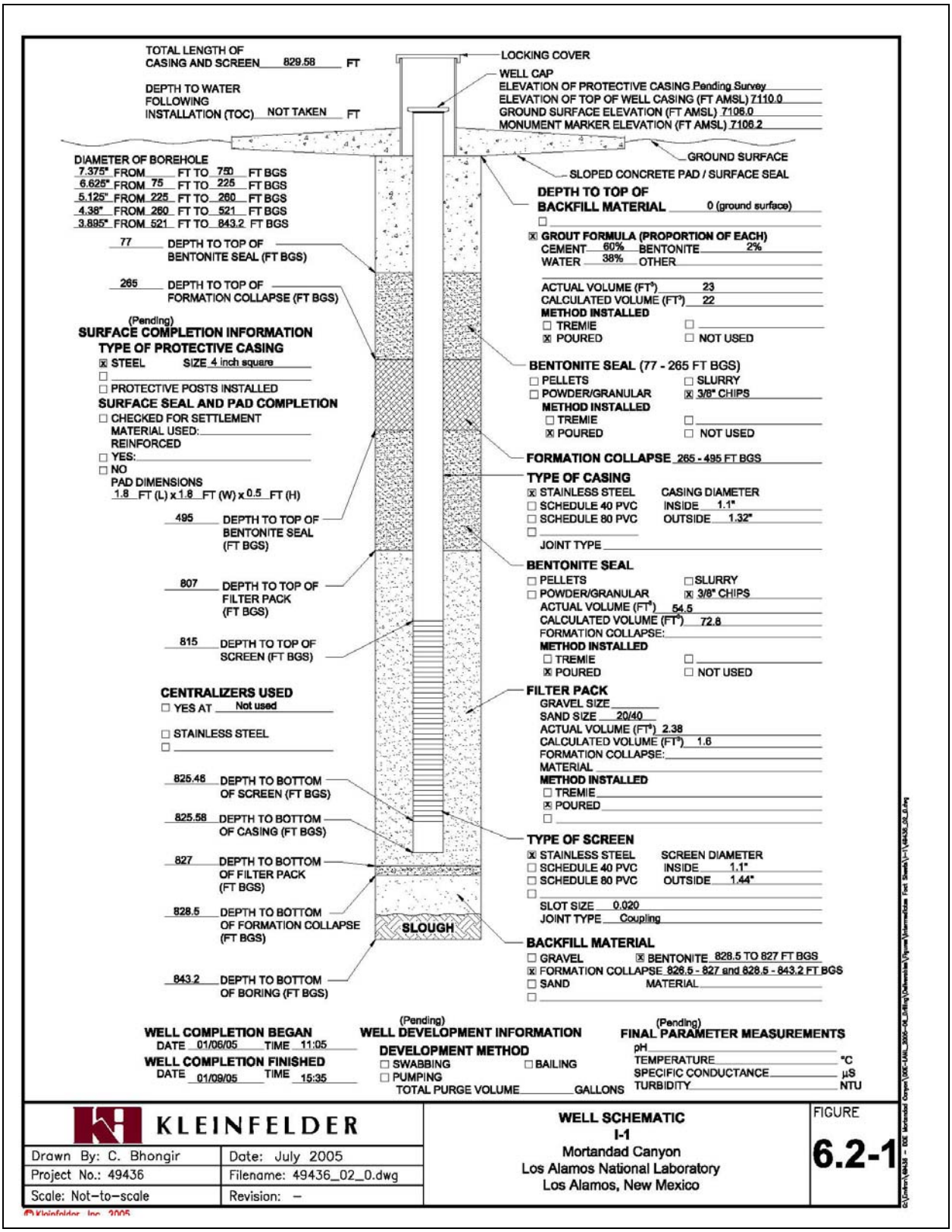
I-1 was constructed in general accordance with LANL's Environmental Restoration standard operating procedure (SOP) 05.01 (LANL, 2001) using 1.1-in. inside diameter /1.32-in. OD, type A304, stainless-steel casing fabricated to American Society for Testing and Materials A312 standards. External couplings, also of type A304 stainless steel, were used to connect individual casing and screen joints. A single 10-ft section of 1.44-in. OD, stainless steel, 0.020-in. slot size, wire-wrapped well screen was installed from 815 to 825.46 ft bgs (Figure 6.2-1). The screen was pre-packed with 20/40 silica sand that was contained with a stainless-steel mesh.

Prior to installing the well casing, the bottom of the corehole was tagged at 828.5 ft bgs, indicating that 14.5 ft of slough had accumulated in the bottom of the corehole. Annular fill materials were poured from the ground surface through the Tubex® casing. Bentonite chips (⅜-in. size) were placed on top of the sloughed material to a depth of 827 ft bgs. A primary filter pack comprised of 20/40 silica sand was placed from 827 to 807 ft bgs. Bentonite chips were placed from 807 to 495 ft bgs. Due to caving of the formation, slough filled the annulus from 495 to 265 ft bgs. The Tubex® casing was pulled and bentonite chips were placed in the annulus to a depth 77 ft bgs. Cement grout with 2% bentonite was placed in the corehole from 77 ft bgs to ground surface. Table 6.2-1 summarizes the volumes of annular fill materials used to complete I-1.

Table 6.2-1

Annular Fill Materials Used in Well Construction

Material	Volume
Surface seal: cement slurry	67.5 ft^3
Bentonite seal: bentonite chips	54.47 ft^3
Bentonite grout: granular	23 ft^3
Filter sand: 20/40 silica sand	2.375 ft^3


TOTAL LENGTH OF CASING AND SCREEN 829.58 FT
DEPTH TO WATER FOLLOWING INSTALLATION (TOC) NOT TAKEN FT
LOCKING COVER
WELL CAP
ELEVATION OF PROTECTIVE CASING Pending Survey
ELEVATION OF TOP OF WELL CASING (FT AMSL) 7110.0
GROUND SURFACE ELEVATION (FT AMSL) 7106.0
MONUMENT MARKER ELEVATION (FT AMSL) 7106.2
GROUND SURFACE
SLOPED CONCRETE PAD / SURFACE SEAL
DIAMETER OF BOREHOLE
7.375" FROM FT TO 750 FT BGS
6.625" FROM 75 FT TO 225 FT BGS
5.125" FROM 225 FT TO 260 FT BGS
4.38" FROM 260 FT TO 521 FT BGS
3.895" FROM 521 FT TO 843.2 FT BGS
DEPTH TO TOP OF BACKFILL MATERIAL 0 (ground surface)
☒ GROUT FORMULA (PROPORTION OF EACH)
CEMENT 60% BENTONITE 2%
WATER 38% OTHER
ACTUAL VOLUME (FT³) 23
CALCULATED VOLUME (FT³) 22
METHOD INSTALLED
☐ TREMIE
☒ POURED
☐ NOT USED
77 DEPTH TO TOP OF BENTONITE SEAL (FT BGS)
265 DEPTH TO TOP OF FORMATION COLLAPSE (FT BGS)
(Pending)
SURFACE COMPLETION INFORMATION
TYPE OF PROTECTIVE CASING
☒ STEEL SIZE 4 inch square
☐ PROTECTIVE POSTS INSTALLED
SURFACE SEAL AND PAD COMPLETION
☐ CHECKED FOR SETTLEMENT
MATERIAL USED:
REINFORCED
☐ YES:
☐ NO
PAD DIMENSIONS
1.8 FT (L) x 1.8 FT (W) x 0.5 FT (H)
BENTONITE SEAL (77 - 265 FT BGS)
☐ PELLETS ☐ SLURRY
☐ POWDER/GRANULAR ☒ 3/8" CHIPS
METHOD INSTALLED
☐ TREMIE
☒ POURED
☐ NOT USED
FORMATION COLLAPSE 265 - 495 FT BGS
TYPE OF CASING
☒ STAINLESS STEEL
☐ SCHEDULE 40 PVC
☐ SCHEDULE 80 PVC
CASING DIAMETER
INSIDE 1.1"
OUTSIDE 1.32"
JOINT TYPE
495 DEPTH TO TOP OF BENTONITE SEAL (FT BGS)
BENTONITE SEAL
☐ PELLETS ☐ SLURRY
☐ POWDER/GRANULAR ☒ 3/8" CHIPS
ACTUAL VOLUME (FT³) 54.5
CALCULATED VOLUME (FT³) 72.8
FORMATION COLLAPSE:
METHOD INSTALLED
☐ TREMIE
☒ POURED
☐ NOT USED
807 DEPTH TO TOP OF FILTER PACK (FT BGS)
815 DEPTH TO TOP OF SCREEN (FT BGS)
CENTRALIZERS USED
☐ YES AT Not used
☐ STAINLESS STEEL
FILTER PACK
GRAVEL SIZE
SAND SIZE 20/40
ACTUAL VOLUME (FT³) 2.38
CALCULATED VOLUME (FT³) 1.6
FORMATION COLLAPSE:
MATERIAL
METHOD INSTALLED
☐ TREMIE
☒ POURED
825.48 DEPTH TO BOTTOM OF SCREEN (FT BGS)
825.58 DEPTH TO BOTTOM OF CASING (FT BGS)
827 DEPTH TO BOTTOM OF FILTER PACK (FT BGS)
828.5 DEPTH TO BOTTOM OF FORMATION COLLAPSE (FT BGS)
843.2 DEPTH TO BOTTOM OF BORING (FT BGS)
SLOUGH
TYPE OF SCREEN
☒ STAINLESS STEEL
☐ SCHEDULE 40 PVC
☐ SCHEDULE 80 PVC
SCREEN DIAMETER
INSIDE 1.1"
OUTSIDE 1.44"
SLOT SIZE 0.020
JOINT TYPE Coupling
BACKFILL MATERIAL
☐ GRAVEL ☒ BENTONITE 828.5 TO 827 FT BGS
☒ FORMATION COLLAPSE 826.5 - 827 and 828.5 - 843.2 FT BGS
☐ SAND MATERIAL
WELL COMPLETION BEGAN
DATE 01/06/05 TIME 11:05
WELL COMPLETION FINISHED
DATE 01/09/05 TIME 15:35
(Pending)
WELL DEVELOPMENT INFORMATION
DEVELOPMENT METHOD
☐ SWABBING ☐ BAILING
☐ PUMPING
TOTAL PURGE VOLUME GALLONS
(Pending)
FINAL PARAMETER MEASUREMENTS
pH
TEMPERATURE °C
SPECIFIC CONDUCTANCE µS
TURBIDITY NTU
KLEINFELDER
Drawn By: C. Bhongir
Date: July 2005
Project No.: 49436
Filename: 49436_02_0.dwg
Scale: Not-to-scale
Revision: –
WELL SCHEMATIC
I-1
Mortandad Canyon
Los Alamos National Laboratory
Los Alamos, New Mexico
FIGURE
6.2-1

7.0 WELL DEVELOPMENT, AQUIFER TESTING, AND PUMP INSTALLATION

A perched intermediate zone was not encountered while coring I-1; thus, well development, aquifer testing, and pump installation have not been done.

8.0 WELLHEAD COMPLETION, SURVEY, AND SITE RESTORATION

8.1 Wellhead Completion

On March 2, 2005, a reinforced (2,500 pounds per square inch) concrete pad, 1.8-ft wide by 1.8-ft long by 6-in. thick, was installed around the well casing to provide long-term structural integrity to the well. A brass survey cap was embedded in the northwest corner of the pad. A 4-in.-square steel monument made of high-carbon steel with a locking lid was installed over the well casing. The top of the monument extended above the ground surface by approximately 3 ft.

8.2 Geodetic Survey

On March 24, 2005, the ground surface, well casing, and brass cap at the I-1 wellhead were surveyed by ASTS, Inc., of Albuquerque, New Mexico. The survey data are presented in Table 8.2-1.

Table 8.2-1
Geodetic Data

Description	Northing	Easting	Elevation*
Ground surface	1769958.20	1628044.06	7106.0
Brass cap in I-1 pad	1769957.39	1628044.51	7106.2
Top of stainless-steel casing	1769956.54	1628044.66	7110.0

* Measured in ft above mean sea level relative to the National Geodetic Vertical Datum of 1929

8.3 Site Restoration Activities

Cuttings produced during coring and drilling have been sampled and, upon receipt of NMED approval, will be thinly spread over the site. Once approval has been received, other site-restoration activities will be conducted, including backfilling and leveling of the cuttings pit and reseeding.

9.0 DEVIATIONS FROM THE FINAL DRILLING PLAN

In general, drilling, sampling, and well construction at I-1 was performed in accordance with the "Final Drilling Plan for Intermediate Wells, Mortandad Canyon" (Kleinfelder, 2004). Deviations from planned activities were as follows:

- Core was not collected from ground surface to 75 ft bgs
- The filter pack used with 0.020-in. slot size well screen was comprised of 20/40 silica rather than 10/20 silica sand

10.0 ACKNOWLEDGEMENTS

ASTS, Inc., conducted the final geodetic survey of finished well components.

EnviroWorks, Inc., provided site preparation services.

PMC Terranear collected core samples for radionuclide analysis after well completion.

Spectrum Exploration, Inc., provided drilling services.

11.0 REFERENCES

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Los Alamos National Laboratory, 2001. "Environmental Restoration Project Standard Operating Procedure for Well Construction, Revision 3," ER-SOP-5.01, April 2001.

Appendix A

Corehole Video Log

Appendix B

Lithologic Log

Appendix B - Lithologic Descriptions of Drill Cuttings in Borehole I-1

Geologic Unit	Lithologic Description	Sample Interval (ft)	Elevation Range (ft above msl)
	Not Cored from 0 to 75 feet. **Note: drill core was collected from the interval of 75 ft to 843.2 ft bgs. Descriptions presented in this lithologic log are primarily based on those made during visual examination of drill core. Stratigraphic contacts are based on available information from review of drill core and limited geophysical logs. Unrecovered and/or sampled core in sections of less than 5 ft are not noted unless relevant to lithologic description.**	0-75	7106.0-7031.0
Qbt2, Tshirege Member of the Bandelier Tuff	Tuff, pale red (10YR 6/2) to grayish orange pink (10YR 8/2), moderately welded. Ash matrix; felsic crystal rich with 8% coarse to very coarse felsic crystals; 1-2% fine to medium oxidized mafic crystals, yellow/red in color; 8-10% devitrified brown, purple, and light gray pumice, up to 20 mm long and 10 mm wide, relic fibrous structure and sugary texture, occasional felsic phenocrysts.	75-86	7031.0-7020.0
	Tuff, grayish orange pink (5 YR 7/2), moderately welded. Ash matrix; 12-15% medium to coarse felsic crystals; 0-1% oxidized medium mafic crystals; 20% gray, purple, and olive gray devitrified pumice with sugary texture; pumice up to 12 mm long by 6 mm wide.	86-92	7020.0-7014.0
	Tuff, as above; pumice up to 30 mm long by 25 mm wide, pumice contain 5% very coarse felsic phenocrysts, relic fibrous structure and sugary texture.	92-94	7014.0-7012.0
	As above; 20% devitrified pumice with sugary texture, pumice is light purple gray up to 45 mm long, pumice contain 3-5% felsic phenocrysts.	94-97.5	7012.0-7008.5
	As above, smaller pumice, up to 10 mm long by 5 mm wide, pumice light purple gray to brown with relic fibrous structure and sugary texture. Note: horizontal fracturing of core at 100.5 feet.	97.5-100.5	7008.5-7005.5
Qbt1v, Tshirege Member of the Bandelier Tuff	Tuff, pinkish gray (5YR 8/1), poorly welded. Ash matrix; 15% coarse to very coarse felsic crystals; 25-30% devitrified pumice with relic fibrous structure and sugary texture, up to 22 mm, grayish brown. **Note: the contact of Unit 2 of the Tshirege Member of the Bandelier Tuff (Qbt 2) and the contact with the underlying Unit 1v of the Tshirege Member of the Bandelier Tuff (Qbt 1v) is interpreted to be at 100.5 ft bgs.**	100.5-102.5	7005.5-7003.5
	No recovery and/or available core sampled. Core unavailable for examination.	102.5 - 107.5	7003.5-6998.5
	As above; slight decrease in welding; pumice up to 22 mm long by 15 mm wide, contain very coarse bipyramidal quartz phenocrysts; possible rhyolitic lithic fragment to 10mm.	107.5-117.5	6998.5-6988.5
	Tuff, pinkish gray (10YR 8/2), poorly welded. Ash matrix; 10-12% coarse to very coarse felsic crystals; 3% light gray to gray lithic fragments to 5 mm - possible rhyolite; 20% brown devitrified pumice with relic fibrous structure, up to 10 mm long.	117.5-120	6988.5-6986.0
	As above; pumice increase to 45%, up to 50 mm long by 20 mm wide with 5% very coarse felsic phenocrysts.	120-123	6986.0-6983.0
	Tuff, light brown (5YR 5/6); Ash matrix; 15% coarse to very coarse felsic crystals; 3% gray lithic fragments to 2mm; 12-15% brown devitrified pumice, up to 10 mm long, sugary texture and minor relic fibrous structure; matrix moist and clayey - possible weathering surface.	123-127.5	6983.0-6978.5
Qbt1g, Tshirege Member of the Bandelier Tuff	Tuff, light brown (5YR 5/6). Ash matrix; 20-25% coarse to very coarse felsic crystals; 5% dark gray lithic fragments to 20 mm, fine grained - possible dacite; 10% white pumice to 10 mm, very soft; moist and very clayey. **Note: the base of Qbt 1v and the contact with the underlying Unit 1g of the Tshirege Member of the Bandelier Tuff (Qbt 1g) is interpreted to be at 127.5 ft bgs.**	127.5-129	6978.5-6977.0
	As above; decrease in clay; pumice vitric with fibrous texture and 5-8% felsic phenocrysts.	129-131	6977.0-6975.0
	As above; pumice increase to 40-45%.	131-137.5	6975.0-6968.5
	Tuff, grayish orange (10YR 7/4), poorly welded. Ash matrix; 8-10% medium to very coarse felsic crystals; 50% white vitric pumice with fibrous texture and 10% felsic phenocrysts, up to 30 mm wide by 35 mm long.	137.5-144	6968.5-6962.0
	As above; color change to very pale orange (10YR 8/2).	144-149	6962.0-6957.0
	Tuff, very pale orange (10YR 8/2). Ash matrix; 8-10% medium to very coarse felsic crystals; 2% red to gray lithic fragments to 5 mm; 30% white vitric pumice, occasional brown alteration, fibrous texture, up to 20 mm long by 10 mm wide.	149-159	6957.0-6947.0
	Tuff, very pale orange (10YR 8/2), poorly welded. Ash matrix; 8% medium to coarse felsic crystals; 1-2% dark gray lithic fragments to 3 mm; 35% white vitric pumice, 5% very coarse felsic phenocrysts, fibrous texture, up to 30 mm long.	159-172.5	6947.0-6933.5
	As above; decrease in crystal content in ash matrix to 5-6% medium to coarse felsic crystals; decrease in pumice to 15%, pumice up to 12 mm long by 8 mm wide.	172.5-177.5	6933.5-6928.5
	Tuff, very pale orange (10YR 8/2), poorly welded. Ash matrix; 8% medium to coarse felsic crystals; 1-2% dark gray lithic fragments, up to 3 mm; 45-50% white to tan vitric pumice with fibrous texture and 10% very coarse felsic phenocrysts.	177.5-184	6928.5-6922.0

Preliminary Log Compiled from Field Sample Descriptions (Revision A)

Geologic Unit	Lithologic Description	Sample Interval (ft)	Elevation Range (ft above msl)
	As above; 1% yellowish oxidized mafic crystals.	184-195	6922.0-6911.0
	Tuff, very pale orange (10YR 8/2), poorly welded. Ash matrix; 10% medium to coarse felsic crystals; 2-3% dark gray lithic fragments, up to 5 mm, possible dacite; 30% white vitric pumice with fibrous texture and 5-7% coarse to very coarse felsic phenocrysts.	195-199.5	6911.0-6906.5
	Tuff, yellowish orange (5Y 8/1). Ash matrix; 15% coarse to very coarse felsic crystals; 1-2% yellowish oxidized mafic crystals; 10% white vitric pumice, up to 8 mm long.	199.5-200.8	6906.5-6905.2
Qbtt, Tsankawi Pumice Bed of the Tshirege Member of the Bandelier Tuff	Pumice Bed, yellowish orange (5Y 8/1). 85% coarse to very coarse felsic crystals; 2% coarse to very coarse mafic crystals; 13% white vitric pumice up to 10 mm with 1% fine mafic phenocrysts. **Note: the base of Qbt 1g and the contact with the underlying Tsankawi Pumice Bed (Qbtt) is interpreted to be at 200.8 ft bgs.**	200.8-204	6905.2-6902.0
Qct, Cerro Toledo Interval	Volcaniclastic sediments, gravelly sand with fines, light brown (5YR 5/6). Poorly sorted (15-20% gravel, 60-70% sand, 15-20% fines); very fine to very coarse grained sand composed predominately subangular felsic crystals (fine to medium grain size) and pumice with lesser amounts lithic clasts; gravels moderately sorted, predominately white vitric pumice, fine to medium grain size; moist. **Note: the base of the Tsankawi Pumice Bed (Qbtt) and the contact with the underlying Cerro Toledo Interval (Qct) is interpreted to be at 204 ft bgs.**	204-205	6902.0-6901.0
	No recovery and/or available core sampled. Core unavailable for examination.	205-207.5	6901.0-6898.5
	Volcaniclastic sediments, yellowish brown (5Y 8/1); predominantly white vitric pumice up to 10 mm, subangular; 5-7% medium felsic crystals in matrix; 3% red to gray lithic fragments to 5 mm.	207.5-208.5	6898.5-6897.5
	Volcaniclastic sediments, silt with trace sand, light brown (5YR 5/6). Silt and clayey matrix with 3% fine to medium sand grain size felsic crystals, 5% white vitric pumice (trace gravel size up to 5 mm), and 1% fine black mafic crystals; at 209.1ft bgs, 1 cm dusky yellowish brown (10YR 2/2) silt/organic layer; moist.	208.5-209.5	6897.5-6896.5
	No recovery and/or available core sampled. Core unavailable for examination.	209.5-212.5	6896.5-6893.5
	Volcaniclastic sediments, (pumiceous) gravelly sand with minor fines, grayish orange (10YR 7/4). Poorly sorted (20% gravel, 60% sand, 15-20% silt/clay); Sands composed of equal amounts of felsic crystals, lithics, pumice, rounded to subangular, felsic crystals very fine to medium; gravel up to 10mm, composed of white vitric pumice and intermediate composition volcanics and possible rhyolite, subrounded.	212.5-214.2	6893.5-6891.8
	No recovery and/or available core sampled. Core unavailable for examination.	214.2-217.5	6891.8-6888.5
	Volcaniclastic sediments, gravelly sand, dark yellowish orange (10YR 6/6). Poorly sorted sand, very fine to very coarse grain size, composed of 30-40% very small felsic crystals, angular to subrounded, 30-40% very fine to coarse lithics, and 25% pumice; well sorted gravel composed of fine to medium grain size intermediate composition volcanic lithics, trace pumice, rounded to subangular; dry.	217.5-220	6888.5-6886.0
	Very poor recovery, lithic fragments to 30 mm, intermediate volcanic composition.	220-222.5	6886.0-6883.5
	Core not sampled. Small volumes of cuttings collected at air discharge line from 222.5 ft to 260 ft bgs.	222.5-230	6883.5-6876.0
	As described at 217.5 feet; sandy gravel with fines. Core not sampled. Small volumes of cuttings periodically collected at air discharge line from 222.5 ft to 260 ft bgs.	230-234	6876.0-6872.0
	Volcaniclastic sediments, gravelly sand with silt, dark yellowish orange (10YR 6/6). Poorly sorted (30-40% grave, 40-50% sand, 10-15% fines); poorly sorted sand composed of predominately lithic and very fine to medium grained felsic crystals with lesser amounts of vitric pumice, rounded to angular; gravel composed of intermediate composition volcanic clasts up to 1cm, angular to rounded, with lesser amounts of vitric pumice up to o.5 cm; dry. Core not sampled. Small volumes of cuttings collected at air discharge line from 222.5 ft to 260 ft bgs.	234-239	6872.0-6867.0
	Volcaniclastic sediments, sandy silt with minor gravel, grayish orange (10YR 7/4). Moderately sorted (5-10% gravel, 15-20% sand, 65-70% fines); well sorted sand (very fine to fine) felsic crystals with minor amounts of lithic clasts, rounded to subangular; gravel composed of white vitric pumice up to 8 mm; dry. Core not sampled. Small volumes of cuttings collected at air discharge line from 222.5 ft to 260 ft bgs.	239-244	6867.0-6862.0
Qbo, Otowi Member of the Bandelier Tuff	Tuff, moderate orange pink (5YR 8/4); ash matrix with 8-10% medium to very coarse felsic crystals; 2% gray lithic fragments to 4 mm; 15% white to tan vitric pumice with fibrous texture. Core not sampled. Small volumes of cuttings collected at air discharge line from 222.5 ft to 260 ft bgs. **Note: the base of the Cerro Toledo Interval (Qct) and the contact with the underlying Otowi Member of the Bandelier Tuff (Qbo) is interpreted to be at 244 ft bgs.**	244-254	6862.0-6852.0
	As above; pumice up to 15 mm with 15% very coarse felsic phenocrysts. Core not sampled. Small volumes of cuttings collected at air discharge line from 222.5 ft to 260 ft bgs.	254-260	6852.0-6846.0
	Tuff, dark yellowish orange (10YR 6/6), poorly welded coarse felsic crystals; 25% subrounded gray lithic fragments up to 40 mm by 20 mm, 15% white vitric pumice with fibrous texture.	260-262.5	6846.0-6843.5
	No recovery and/or available core sampled. Core unavailable for examination.	262.5-277.5	6843.5-6828.5

Preliminary Log Compiled from Field Sample Descriptions (Revision A)

Geologic Unit	Lithologic Description	Sample Interval (ft)	Elevation Range (ft above msl)
	Tuff, grayish orange (10YR 7/4), poorly welded. Ash matrix; 5% felsic crystals; 3% gray lithic fragments up to 5 mm; 15% yellowish altered pumice with 10% very coarse felsic phenocrysts.	277.5-282.5	6828.5-6823.5
	As above; 10% pumice, up to 7 mm; gray dacite fragment 40 mm by 30 mm, subangular.	282.5-288.5	6823.5-6817.5

Preliminary Log Compiled from Field Sample Descriptions (Revision A)

Geologic Unit	Lithologic Description	Sample Interval (ft)	Elevation Range (ft above msl)
	Tuff, grayish orange (10YR 7/4), poorly welded. Ash matrix; 6-8% medium to very coarse felsic crystals; 3% gray lithic fragments, up to 4 mm; 12-15% yellow altered pumice, up to 15 mm.	288.5-298	6817.5-6807.0
	Tuff, grayish orange (10YR 7/4), poorly welded. Ash matrix; 8-10% medium to coarse felsic crystals; 20% gray dacite fragments, up to 20 mm; 10% yellowish pumice, 5% felsic phenocrysts, up to 10 mm.	298-318	6807.0-6787.0
	As above; more indurated; increase in coarse to very coarse felsic crystals.	318-319	6787.0-6786.0
	Tuff, very pale orange (10YR 8/2), poorly welded. Ash matrix; 8-10% medium to very coarse felsic crystals; 2-3% gray lithic fragments, up to 5 mm; 12-15% yellow altered pumice, 5% felsic phenocrysts, up to 15 mm.	319-344	6786.0-6761.0
	As above; occasional gray dacite fragment up to 20 mm.	344-365	6761.0-6740.0
	Tuff, pale yellowish brown (10YR 6/2), poorly welded. Ash matrix; 3-5% medium to very coarse felsic crystals; 1% red to gray lithic fragments to 20 mm; 10% white vitric pumice with fibrous texture, up to 10 mm.	365-400	6740.0-6705.0
	Tuff, very pale orange (10YR 8/2), poorly welded. Ash matrix; 5% coarse to very coarse felsic crystals; 2-3% red to gray subrounded lithic fragments, up to 10 mm; 5% yellow to tan vitric pumice with 10% very coarse felsic phenocrysts, up to 10 mm.	400-419	6705.0-6686.0
	As above; white to yellow vitric pumice up to 15 mm with 10% very coarse felsic phenocrysts.	419-435	6686.0-6670.0
	Tuff, very pale orange (10YR 8/2). Ash matrix; 5% medium to coarse felsic crystals; 5% gray lithic fragments, up to 10 mm, subangular to subrounded, occasional angular fragment to 20 mm; 10% yellowish to white vitric pumice.	435-464	6670.0-6641.0
	As above; increase in pumice content to 10-12%; pumice up to 30 mm.	464-472	6641.0-6633.0
	Tuff, very pale gray (10YR 8/2) to yellowish gray (5Y 8/1), poorly welded - slight increase in welding from above. Ash matrix; 5% medium to very coarse felsic crystals; 5% gray lithic fragments up to 3 mm; 10% white vitric pumice up to 20 mm.	472-477.5	6633.0-6627.5
Qbog, Guaje Pumice Bed of the Otowi Member of the Bandelier Tuff	Pumice Bed, very pale orange (10YR 8/2) to yellowish gray (5Y 8/1). Minor ash; 50-80% white vitric pumice; 10% medium to very coarse felsic crystals; 20-25% gray lithic fragments up to 5 mm. **Note: the base of the Otowi Member of the Bandelier Tuff (Qbo) and the contact with the underlying Guaje Pumice Bed is interpreted to be at 477.5 ft bgs.**	477.5-479.5	6627.5-6625.5
	As above, color change to very light gray (N8)	479.5-482	6625.5-6623.0
	As above, poorly welded; increase in pumice to 80% white, vitric, up to 20 mm, fibrous texture.	482-484	6623.0-6621.0
	As above, increase in gray lithic fragments to 8%.	484-490	6621.0-6615.0
	As above, yellowish brown lithic fragment to 10 mm.	490-494	6615.0-6611.0
	As above, increase in yellowish brown lithic fragments to 10-15%, up to 30 mm, subangular.	494-498.8	6611.0-6606.2
Silty Horizon, unassigned	Silty Horizon, clayey silt with fine sand, core disturbed- intermixing with overlying pumice, moderate yellowish brown (10YR 5/4); moderately sorted, low to medium plasticity; trace subrounded dark clasts up to 1.5 cm; vitric pumice, up to large 5 cm; moist. **Note: The base of the Guaje Pumice Bed (Qbog) and the contact with the underlying silty horizon is interpreted to be at 499 ft bgs.**	498.8-499.3	6606.2-6605.7
	No recovery and/or available core sampled. Core unavailable for examination.	499.3-502.5	6605.7-6602.5
Tt, Tschicoma Lava Flow, unassigned	Lava flow, poor recovery, dark gray (N3), massive. Poor recovery, several broken fragments up to 6cm, aphanitic groundmass; ferromagnesium phenocrysts- pyroxene possibly olivine, <1%, very small (<1 mm), varied colored including greenish black, yellow brown, yellowish green; trace feldspar phenocrysts; trace vesicles; occasional weathered and subrounded surfaces. **Note: The base of the overlying Silty Horizon and the contact with the underlying Tschicoma Lava Flow (Tt) is poorly defined due to lack of recovery.**	502.5-502.7	6602.5-6602.3
	No recovery and/or available core sampled. Core unavailable for examination.	502.7-517.5	6602.3-6587.5
	As above, possible fracture with minor yellow weathering.	517.5-518.5	6587.5-6586.5
	As above; 1% ferromagnesium phenocrysts (pyroxene and possibly olivine), irregular shape, <1 mm, pale green.	518.5-526	6586.5-6579.0
	Lava flow, dark gray (N3), massive. Aphanitic groundmass; trace ferromagnesium (pyroxene and possibly olivine) phenocrysts, varied colored including dark green, dark brownish green, pale yellowish brown, irregular shaped, < 1 mm; feldspar phenocrysts <1%, white, rectangular, strong cleavage - some alteration along rims.	526-530	6579.0-6575.0
	Lava flow, dark gray (N3), massive with trace vesicles. 0-1% phenocrysts, ferromagnesium phenocrysts green to dark brownish green, rounded to irregular shapes.	530-543.6	6575.0-6561.4
	As above, trace feldspar phenocryst.	543.6-546	6561.4-6559.0
	Lava flow, very dusky red (10R 2/2); massive, increase in vesicles. Aphanitic groundmass; 0-1% ferromagnesium and feldspar phenocrysts; secondary crystal growths in vesicles, white to very light gray, very small (<1 mm).	546-548	6559.0-6557.0
	As above, color change to dark gray (N3), variable concentration of vesicles and secondary crystal growths.	548-555.4	6557.0-6549.6

Preliminary Log Compiled from Field Sample Descriptions (Revision A)

Geologic Unit	Lithologic Description	Sample Interval (ft)	Elevation Range (ft above msl)
	Lava flow, dark gray (N3), massive. 0-1% greenish ferromagnesium phenocrysts, irregular to rounded; trace feldspar phenocrysts, irregular to rounded.	555.4-563.5	6549.6-6541.5
	Lava flow, medium dark gray (N4), massive. Aphanitic groundmass; very weakly porphyritic, <1% phenocrysts ferromagnesium (pyroxene possibly olivine), dark olive green.	563.5-574	6541.5-6531.0
	As above; trace vesicles with secondary white crystal growths, very small.	574-575.3	6531.0-6529.7
	Lava flow, medium dark gray (N4), massive. Aphanitic groundmass; very weakly porphyritic, <1% phenocrysts ferromagnesium (pyroxene possibly olivine), dark olive green. Lava flow structures at 575.3 and 580.1 ft bgs.	575.3-585	6529.7-6520.0
	Lava flow, medium dark gray (N4), massive. 1% ferromagnesium (pyroxene possible olivine) phenocrysts, varied colored including dark yellow, greenish brown, blackish brown; feldspar phenocrysts rare; secondary crystal growths infill vesicles; minor reddish brown staining.	585-590	6520.0-6515.0
	Lava flow, brownish gray (5YR 4/1), massive with trace vesicles possibly aligned to flow. Trace ferromagnesium phenocrysts (pyroxene possible olivine), dark colored, irregular to subrounded surfaces; secondary white/light gray crystal growths, <1 mm.	590-600	6515.0-6505.0
	As above, color change to greenish (5GY 2/1).	600-610	6505.0-6495.0
	Lava flow, brownish gray (5YR 4/1), massive to moderately vesicular. Aphanitic groundmass; very weakly porphyritic, 0-1% dark green to blackish green ferromagnesium phenocrysts (pyroxene and possibly olivine), <1 mm.	610-634	6495.0-6471.0
	Lava flow, brownish gray (5YR 4/1); massive with trace vesicles; <1% dark blackish green ferromagnesium phenocrysts, pyroxene - possible olivine.	634-640	6471.0-6465.0
	As above, medium dark gray (N4), increase vesicles up to 1 cm.	640-644	6465.0-6461.0
	Lava flow, medium dark gray (N4), massive, trace vesicles. Aphanitic groundmass; trace ferromagnesium (pyroxene and possibly olivine) phenocrysts, dark blackish green, <1 mm; secondary crystal growths include white/light gray growths, pale green prismatic needle-like growths, and fine dark colored blade-like crystals (possibly hematite).	644-660	6461.0-6445.0
	Lava flow, dark gray (N3), massive, non-vesicular to weakly vesicular. Aphanitic groundmass; very weakly porphyritic with ferromagnesium phenocrysts up to 0.2 cm; secondary crystal growths as described above; horizontal to sub-horizontal fractures stained with iron oxide at 670 ft bgs; small rounded fragments at 666 ft bgs.	660-675	6445.0-6430.0
	Lava flow, medium gray (N5), massive, non-vesicular. Aphanitic groundmass; <1% ferromagnesium phenocrysts (pyroxene and possibly olivine), <1 mm, dark blackish brownish green; very fine secondary crystal growths, white; iron oxide stained fractures at 685 ft bgs.	675-690.5	6430.0-6414.5
	As above, trace vesicles; fracture zone, near horizontal and near vertical, iron oxide staining on fracture surfaces, clay in near vertical fracture.	690.5-701.5	6414.5-6403.5
	Lava flow, medium gray (N5) to brownish gray (5YR 4/1); aphanitic; massive with trace vesicles; subvertical fractures; iron oxide with clay fracture surfaces; secondary crystal growths - white, <1 mm, and <1 mm brown blades (possible hematite); phenocryst poor - occasional dark greenish brown ferromagnesium crystal.	701.5-720	6403.5-6385.0
	As above; mottled medium gray (N5) with brownish gray (5YR 4/1), phenocryst poor.	720-725	6385.0-6380.0
	Lava flow, light gray (N7) to medium gray (N5), massive. Aphanitic groundmass; phenocryst poor; secondary white and brown crystal growths, up to 30-40% of core surface (patch-like appearance); possible fracture at 736 ft bgs.	725-749	6380.0-6356.0
	As above, core lacks secondary crystal growths.	749-754	6356.0-6351.0
	Lava flow, light gray (N7), massive, fractured. Aphanitic groundmass; rare ferromagnesium phenocrysts; fractured zone, core appears as frequent horizontal separations with Fe/Mn staining on surfaces from 754 - 759 ft bgs; clay accumulation on fracture surfaces at 758 ft bgs.	754-770.6	6351.0-6324.4
	Lava flow with minor silt/clay, moderate brown (5YR 4/4) to medium light gray (N6), massive, fractured. Aphanitic groundmass, core is less dense, gritty texture; trace ferromagnesium phenocryst and clear feldspar phenocrysts; highly fractured, altered, moderate brown silt/clay.	770.6-772	6324.4-6323.0
	As above, rubble zone, several near vertical fractures, altered.	772-774	6323.0-6321.0
	As above, fractured massive lava flow with minor silt/clay, moderate brown (5YR 4/4) to medium light gray (N6).	774-780	6321.0-6315.0
	As above, rubble zone.	780-782	6315.0-6313.0
	Lava flow, medium light gray (N6), massive, fractured. Aphanitic with rare ferromagnesium phenocrysts, dark olive green; fractured, possible clay accumulation on fracture surfaces.	782-793.1	6313.0-6301.9
	As above, rubble zone.	793.1-795.5	6301.9-6299.5
	As above.	795.5-797	6299.5-6298.0

Preliminary Log Compiled from Field Sample Descriptions (Revision A)

Geologic Unit	Lithologic Description	Sample Interval (ft)	Elevation Range (ft above msl)
	Lava flow breccia, non-indurated, moderate brown (5YR 3/4). Non-indurated breccia, gravel with silt and sand; poorly-sorted, angular (with occasional subangular) clasts, clasts include large fragments of massive lava flows as above, smaller clasts of moderate reddish brown and black aphanitic clasts with rare ferromagnesium and feldspar phenocrysts; large clast within rubble or brecciated zone from 800 to 801 ft bgs, grayish brown (5YR 3/2), massive with trace vesicles, aphanitic groundmass with trace ferromagnesium phenocrysts; 5-10% fines.	797-808	6298.0-6287.0
	Lava flow breccia with silt/clay, poorly to moderately indurated, varicolored. Clasts of angular aphanitics - rare porphyry, generally aphyric, clasts predominately as from above lava flow; clay, grayish orange (10YR 7/4), waxy appearance, common between clasts.	808-817.3	6287.0-6277.7
Tpf, Puye Formation (fanglomerate)	Volcaniclstic sediments, non-indurated breccia/rubble, varied colored clasts (predominately gray). Varied clasts including weakly prophyritic lava flow clasts as described above, and aphanitic clasts with frequent phenocrysts of feldspar and ferromagnesium phenocrysts; angular, trace subrounded clasts; minor sand/fines; thin clay zone with laminar bedding at approx 817.3 ft bgs. **Note: The above Tschicoma Lava Flow and the contact with the underlying Puye Formation (Tpf) is interpreted to be 817.3 ft bgs.**	817.3-822	6277.7-6273.0
	Volcaniclastic sediments, non-indurated breccia/rubble, large clast (1.3 ft) microcrystalline groundmass with 1% feldspar phenocrysts, trace ferromagnesium phenocrysts.	822-823.3	6273.0-6271.7
	Volcaniclastic sediments, non-indurated breccia/rubble, varied colored. Poorly-sorted clasts of varying size (up to 0.5 ft), aphanitic groundmass, moderately to strongly porphyritic, angular to subangular, generally dark colored (grey to black), 5-10% feldspar phenocrysts, up to 5mm, trace rimmed phenocrysts; occasional clast mottled pink/gray with 2-3% ferromagnesium and 2-3% feldspar phenocrysts; trace fines (silt) and fine sand.	823.3-828.3	6271.7-6266.7
	As above, non-indurated breccia/rubble of porphyritic clasts, poorly- sorted (gravel to cobble size), angular, trace subangular and subrounded surfaces; trace fines.	834-843.2	6266.7-6257.5
	TOTAL BOREHOLE DEPTH (TD) IS AT 843.2 FT BGS.		

NOTES:

Drill core was collected from the interval of 75 ft to 843.2 ft bgs. Descriptions presented in this lithologic log are primarily based on those made during visual examination of drill core.

Contact locations are based on core retrieval and geophysical data. There is general agreement between this borehole log and the geophysics report.

Descriptions of drill core from sedimentary units such as the Quaternary Alluvium, Cerro Toledo Interval and the Puye Formation utilized principles outlined in *Petrology of Sedimentary Rocks* by Robert L. Folk. Color Descriptions were determined using The

Fractures were visually inspected for an approximate orientation. The angle of the fracture surface is approximated from vertical.

The term "percent" (%), as used in the above descriptions, refers to visual estimate of the relative abundance by volume for a given sample component.

REFERENCES:

Folk, Robert L., 1980, *Petrology of Sedimentary Rocks*, Hemphill Publishing Company.
The Geological Society of America, 1991, Rock-Color Chart.