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Characterization Well R-23 Completion Report

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Produced by the Groundwater Protection Program, Risk Reduction & Environmental Stewardship Division

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List of Acronyms and Abbreviations

AITH	Array Induction Tool, Version H
ASTM	American Society for Testing and Materials
bgs	below ground surface
CMR	Combinable Magnetic Resonance
CNTG	Compensated Neutron Tool, Model G
DR	dual rotation
ECS	Elemental Capture Sonde
EES	Earth and Environmental Sciences
EPA	US Environmental Protection Agency
FMI	formation microimager
FMU	Facility Management Unit
FSF	Field Support Facility (part of Risk Reduction and Environmental Stewardship Division)
GPS	global positioning system
GR	gamma radiation
hp	horsepower
IC	ion chromatography

ICPES	inductively coupled plasma emission spectroscopy
ICPMS	inductively coupled plasma mass spectrometry
ID	inner diameter
LANL	Los Alamos National Laboratory
NGS	Natural Gamma Spectroscopy
NTU	nephelometric turbidity unit
OD	outer diameter
psi	pounds per square inch
PVC	polyvinyl chloride
RC	reverse circulation
RRES	Risk Reduction and Environmental Stewardship (Division)
SAP	Sampling and Analysis Plan
TA	technical area
TD	total depth
TLDM	triple detector lithodensity
UR-DTH	under-reaming down-the-hole (hammer bit)
VOC	volatile organic compound
WCSF	waste characterization strategy form
WGII	Washington Group International, Inc.

Metric to US Customary Unit Conversions

Multiply SI (Metric) Unit	by	To Obtain US Customary Unit
kilometers (km)	0.622	miles (mi)
kilometers (km)	3281	feet (ft)
meters (m)	3.281	feet (ft)
meters (m)	39.37	inches (in.)
centimeters (cm)	0.03281	feet (ft)
centimeters (cm)	0.394	inches (in.)
millimeters (mm)	0.0394	inches (in.)
micrometers or microns (µm)	0.0000394	inches (in.)
square kilometers (km^2)	0.3861	square miles (mi^2)
hectares (ha)	2.5	acres
square meters (m^2)	10.764	square feet (ft^2)
cubic meters (m^3)	35.31	cubic feet (ft^3)
kilograms (kg)	2.2046	pounds (lb)
grams (g)	0.0353	ounces (oz)
grams per cubic centimeter (g/cm^3)	62.422	pounds per cubic foot (lb/ft^3)
milligrams per kilogram (mg/kg)	1	parts per million (ppm)
micrograms per gram (µg/g)	1	parts per million (ppm)
liters (L)	0.26	gallons (gal.)
milligrams per liter (mg/L)	1	parts per million (ppm)
degrees Celsius (°C)	9/5 + 32	degrees Fahrenheit (°F)

CHARACTERIZATION WELL R-23 COMPLETION REPORT

ABSTRACT

Characterization well R-23 was installed by Los Alamos National Laboratory (the Laboratory) under implementation of its hydrogeologic work plan. Washington Group International, Inc., under a subcontract to the Laboratory, carried out drilling activities. The Laboratory's Risk Reduction and Environmental Stewardship (RRES) Division directed the R-23 project in accordance with the sampling and analysis plan for the drilling of characterization wells R-16, R-20, R-21, R-23, and R-32 in the vicinity of Technical Area (TA)-54. The well is located on the south side of Pajarito Road approximately 1000 ft west of the intersection of Pajarito Road and State Highway 4 in Pajarito Canyon. The primary purpose of this well is to provide hydrogeologic and water-quality data for regional groundwater near potential contaminant release sites at TA-54.

Hydrologic, geologic, geochemical, and geophysical information obtained during completion and subsequent sampling of well R-23 will provide data for the Laboratory's hydrologic and geologic conceptual models and contribute to implementing a Laboratory-wide groundwater monitoring system. Monitoring this network of wells supports the Laboratory's Groundwater Protection Management Program plan.

The R-23 borehole was drilled to a total depth of 935 ft below ground surface using a combination of conventional mud-rotary drilling, air-rotary drilling, and fluid-assisted dual rotary drilling with casing-advance methods. Geologic strata encountered during drilling operations included, in descending order, alluvium, Otowi ash flows and Guaje Pumice Bed of the Bandelier Tuff, Cerros del Rio lava flows and interbeds, sediments with basalt detritus of probable Cerros del Rio origin, and Santa Fe Group sediments. A possible perched zone was encountered at 470 ft below ground surface, and a sample was collected from this zone and submitted for analysis. A regional groundwater sample was collected during the final stages of well development and submitted for analysis. Based on the analytical results for the two samples, contamination from Laboratory discharges does not appear to be present in the groundwater at this well site.

The well was designed with one screen placed at the top of the regional aquifer. Following development, the completed well was equipped with a dedicated pump on January 8, 2003. The static water level was measured at a depth of 829 ft in the completed well.

1.0 INTRODUCTION

This completion report for characterization well R-23 summarizes preparation, drilling, well construction, well development, and site completion activities conducted from July 9, 2002, to March 13, 2003. Characterization well R-23 is located on the south side of Pajarito Road approximately 1000 ft west of the intersection with State Highway 4 in Pajarito Canyon (Figure 1.0-1). Well R-23 was installed as part of the "Hydrogeologic Workplan," in support of Los Alamos National Laboratory's (LANL or the Laboratory) "Groundwater Protection Management Program Plan" (LANL 1998, 59599; LANL 1996, 70215).

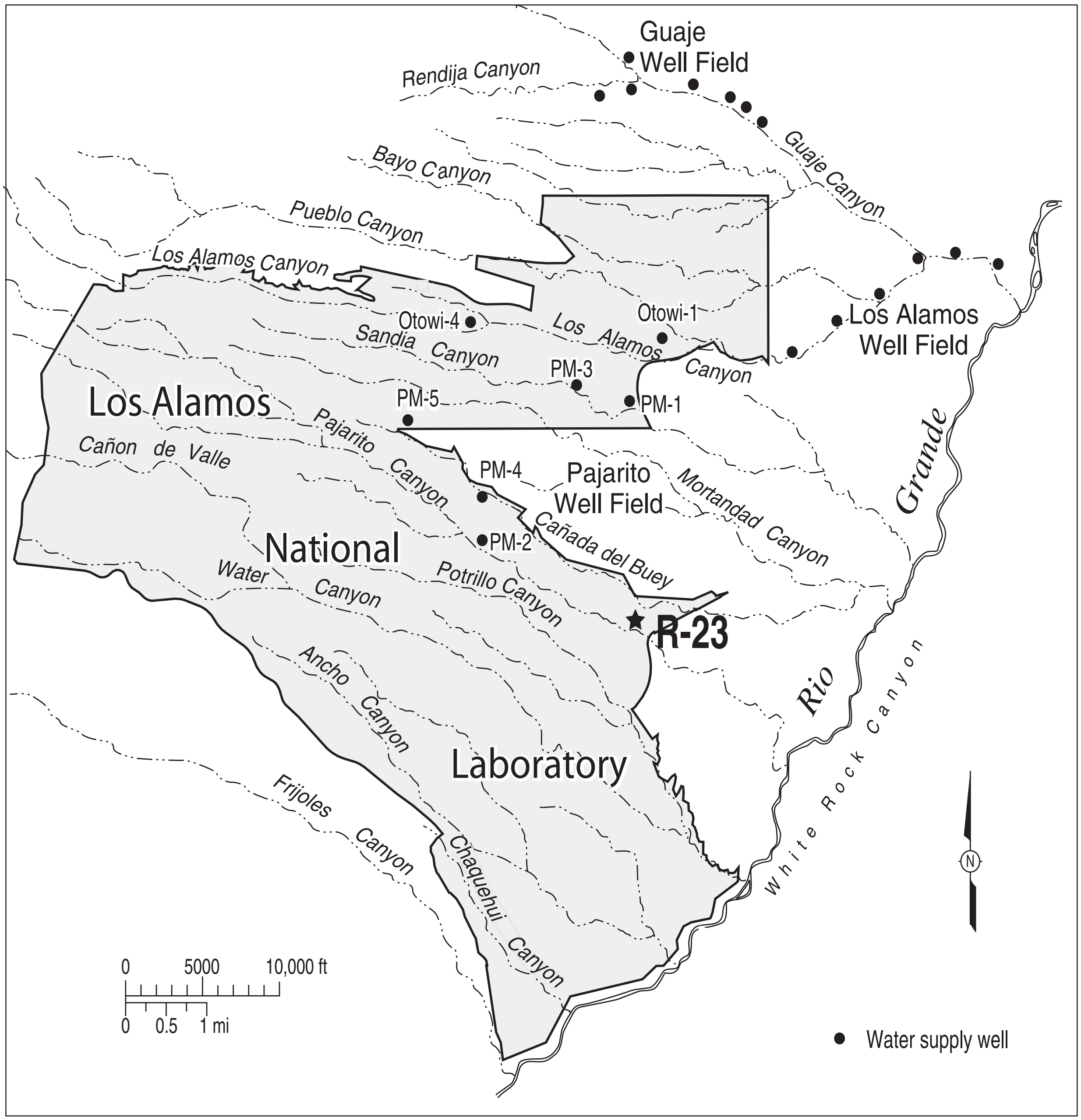


Figure 1.0-1. Location map, characterization well R-23

Characterization well R-23 was funded by the Nuclear Weapons Infrastructure, Facilities, and Construction Program and installed by the Laboratory's Risk Reduction and Environmental Stewardship (RRES) Division. Washington Group International, Inc. (WGII), under contract to the Laboratory, was responsible for executing the drilling activities.

The primary purpose of this characterization well is to provide water-quality, geochemical, hydrologic, and geologic information that would contribute to understanding regional subsurface characteristics and distribution of contaminants resulting from Laboratory releases from Technical Area (TA)-54. Additionally, data from R-23 will be used to update the sitewide hydrologic and geologic conceptual models for the Laboratory.

This report focuses on operational activities associated with the drilling, sampling, installation, and completion of well R-23. Detailed analysis and interpretation of geologic, geochemical, geophysical, and hydrologic data, included as part of previous well completion reports, will be discussed in separate documents to be prepared by the Laboratory.

2.0 PRELIMINARY ACTIVITIES

WGII received contractual authorization to start administrative preparation tasks on June 6, 2002. As part of this preparation, WGII developed a modification to existing site-specific health and safety plan No. 271 to include well R-23. WGII also prepared the R-23 waste characterization strategy form (WCSF). The Laboratory prepared the "Sampling and Analysis Plan (SAP) for the Drilling of Characterization Wells R-16, R-20, R-21, R-23, and R-32 in the Vicinity of TA-54" (LANL 2002, 73390), which included guidance for field personnel in the execution of R-23 field activities. Appendix A of this report compares activities planned in the sampling and analysis plan (SAP) with the work performed. The host facility, Facility Management Unit (FMU) 80, signed a Facility Tenant Agreement to provide access and security control for R-23 activities.

A readiness review meeting was held on July 9, 2002, to discuss all administrative agreements, documents, permits, and plans pertaining to the R-23 project. The Groundwater Investigations Focus Area project leader gave authorization on July 9, 2002, to begin site preparation. The readiness review checklist for drilling activities was signed on July 9, 2002.

K. R. Swerdfeger Construction, Inc., was subcontracted by WGII to conduct site preparation activities. Construction activities included clearing the site, constructing an access road and the drill pad, and constructing a lined cuttings-containment area. Site preparation was conducted from July 16 to 23, 2002.

The R-23 site initially was cleared of small trees and stumps. The construction of the drill pad involved leveling the designated 150-ft-long by 100-ft-wide area with a grader and compacting several layers of base-course gravel. An 80-ft-long by 25-ft-wide by 12-ft-deep cuttings-containment area was excavated along the southwest section of the drill pad and lined with a 6-mil polyethylene liner for storing drilling fluids and cuttings. A 3-ft-high berm was constructed around the containment area, and the entire excavation area was lined with a 6-mil polyethylene liner. A secondary containment area was graded and lined with 6-mil polyethylene to accommodate three 20,000-gal. tank trailers used for storing drilling fluids. Silt fences were constructed around the site, and safety barriers and signs were positioned around the cuttings-containment area and at the site entrance. In addition, the original fencing along Pajarito Road was modified and a new security barbed-wire fence was constructed on the southwest side of the site. Office and supply trailers, generators, and safety lighting equipment were moved to the site during subsequent mobilization of drilling equipment.

3.0 SUMMARY OF DRILLING ACTIVITIES

The drilling objectives for well R-23 were to collect groundwater samples for contaminant analysis, collect drill cuttings for geologic characterization, and provide a borehole for well installation into the regional aquifer. The borehole was drilled to a total depth (TD) of 935 ft below ground surface (bgs).

Dynatec Drilling Company, Inc. (Dynatec), performed all the drilling activities at the R-23 site during July, August, and September 2002. Dynatec provided an Ingersoll-Rand™ T-4 drill rig and a Foremost™ dual rotary (DR)-24 drill rig, along with reverse circulation (RC) drill rods and support equipment. Drill fluid mixing and circulation equipment included a mixing tank and pump assembly, a generator to power the mixing unit, a shaker unit to remove solids from the discharged drilling fluids, and an auxiliary pump. Equipment and fabrication support for drilling activities were provided by RRES Division's Field Support Facility (FSF).

Dynatec assembled its equipment to drill with either mud-rotary or fluid-assisted RC air-rotary drilling techniques to meet changing geologic and drilling conditions. Various additives were mixed with municipal water to minimize fluid loss, improve borehole stability, and facilitate cuttings removal from the borehole. Air-rotary drilling was assisted with a foam mixture that consisted of municipal water mixed with soda ash, QUICK-GEL® (bentonite), LIQUI-TROL® (polymer), and QUICK-FOAM® (surfactant). The fluid mixture used to assist mud-rotary drilling at R-23 typically consisted of municipal water mixed with QUICK-GEL® and LIQUI-TROL® (see Appendix B, on a CD attached to inside back cover). A Baroid mud engineer was on the site to provide expertise on drill fluid formulations. Table 3.0-1 shows the additives and fluids used.

Table 3.0-1
Fluid Additives Used, Characterization Well R-23

Additive	Amount	Unit of Measure
Interval Drilled (0–935 ft)		
Water	55,000	gal.
Bentonite	28,250	lb
LIQUI-TROL®	46	gal.
QUICK-FOAM®	550	gal.
Soda ash	41	lb
Pac-L	700	lb
N-Seal®	1830	lb
Magma Fiber®	2160	lb

Figure 3.0-1 summarizes the well data and depicts the groundwater and geologic conditions encountered. Figure 3.0-2 shows the drilling chronology and other on-site activities.

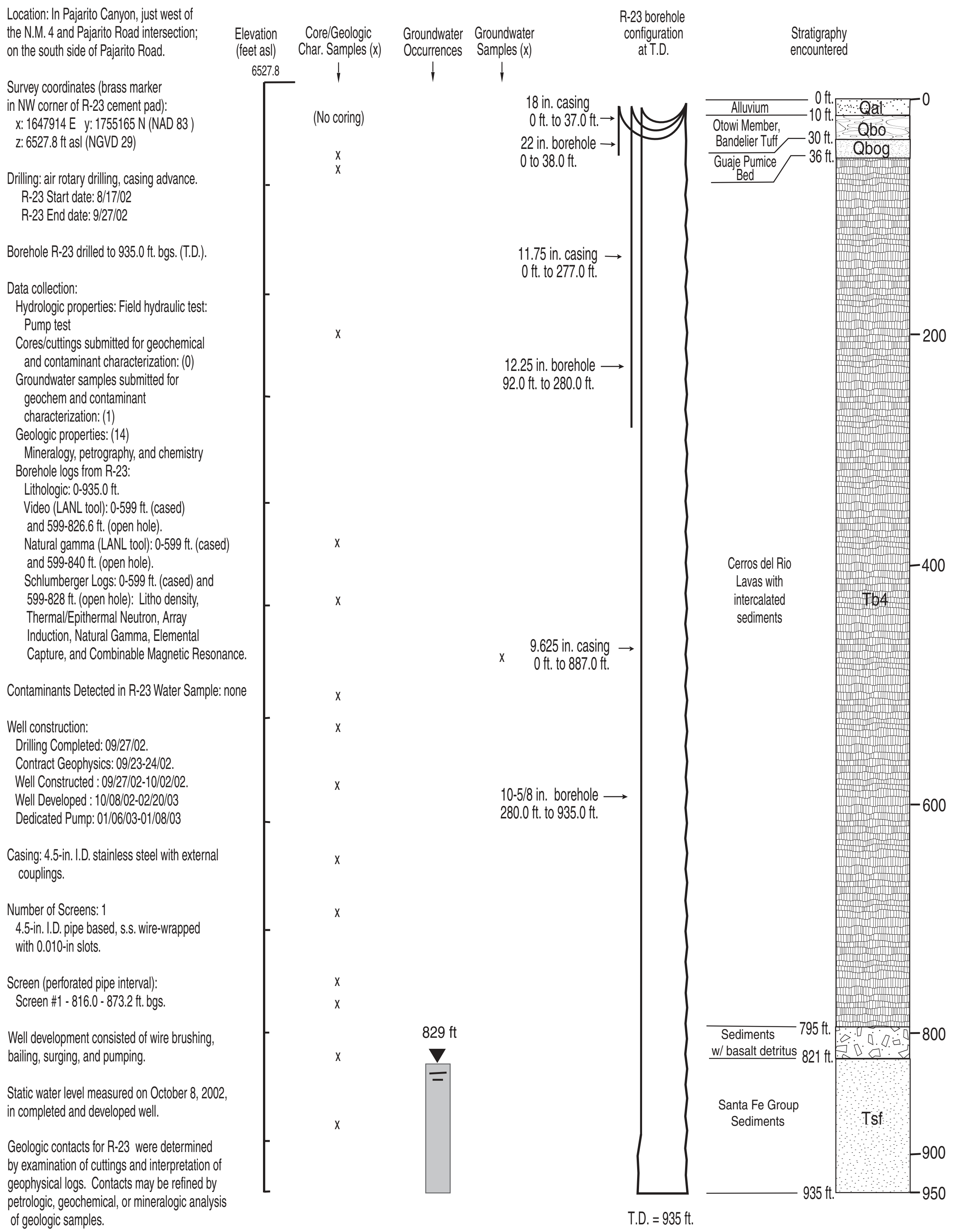


Figure 3.0-1. Well summary data sheet, characterization well R-23

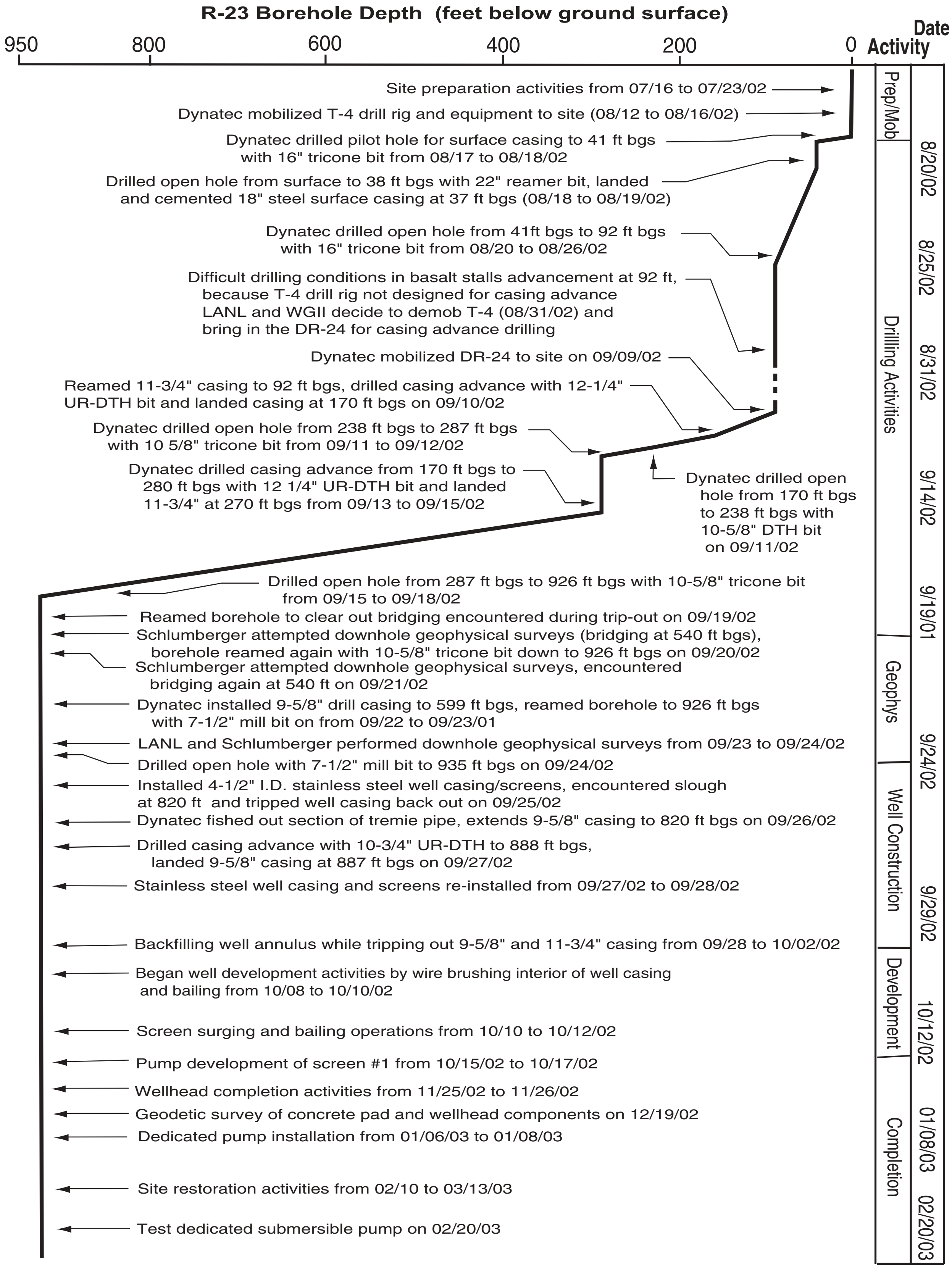


Figure 3.0-2. Operations chronology diagram, characterization well R-23

Drilling Activities

From August 12 through 16, 2002, Dynatec mobilized the Ingersoll-Rand™ T-4 drill rig and support equipment to the site. Dynatec began drilling on August 17, 2002, by advancing a 16-in. tricone drill bit to create a pilot hole for an 18-in. surface casing. On August 18, 2002, the borehole was advanced to 41 ft bgs, and Dynatec then switched to a 22-in. quadcone drill bit to ream a larger borehole from ground surface to 38 ft bgs. An 18-in. surface casing then was installed to 37 ft bgs and cemented in place. Dynatec continued advancing the borehole on August 21, 2002, with a 16-in. tricone drill bit from 41 to 92 ft bgs, where, on August 25, 2002, the drill-bit assembly became stuck in Cerros del Rio basalt. When the drill bit assembly was freed, several attempts were made over the next several days to ream and clear the borehole, without significant progress. Because the T-4 drill rig was not capable of casing-advance drilling, it was demobilized on August 31, 2002, and the Foremost™ DR-24 was used to complete the borehole when that rig finished drilling at well R-16. On September 9, 2002, the Foremost™ DR-24 drill rig was brought to the R-23 site and drilling in the basalt continued.

Drilling resumed on September 10, 2002, when Dynatec reamed an 11.75-in. drill casing through slough in the existing borehole. Dynatec continued drilling with a 12.25-in. under-reaming down-the-hole (UR-DTH) hammer bit, while advancing the 11.75-in. casing to 170 ft bgs where the casing was landed. From this depth, open-hole drilling continued in the basalt with a 10.625-in DTH hammer bit to 238 ft bgs, where Dynatec switched to a 10.65-in. tricone drill bit and continued open-hole drilling. At a depth of 287 ft bgs, Dynatec switched to casing-advance methods in an attempt to eliminate borehole instability and recurring problems with lost circulation of drilling fluids.

Beginning September 13, 2002, Dynatec advanced 11.75-in. drill casing with a 12.25-in. UR-DTH hammer bit from 170 to 280 ft bgs where the casing was landed at 270 ft bgs. Open-hole drilling continued with the 10.625-in. tricone drill bit from 287 ft through the Cerros del Rio basalt. On September 18, 2002, drilling was halted temporarily at 926 ft bgs in Santa Fe Group sediment to obtain a water-level measurement in the regional zone of saturation.

Dynatec resumed drilling operations after a water-level measurement had been taken but had difficulty establishing circulation. Subsequently, bridging was encountered while tripping out the 10.625-in. drill-bit assembly, and the borehole was reamed back down to 926 ft in an attempt to clear out the bridged materials. Drilling operations were terminated due to Laboratory concerns about borehole stability and because the primary data quality objectives had been accomplished (i.e., installing a single-screen well and determining Cerros del Rio basalt thickness).

On September 20, 2002, Schlumberger Inc. (Schlumberger) was unable to run geophysical logging tools through the entire length of the borehole due to an obstruction encountered at 540 ft bgs. Dynatec again reamed out the borehole with a 10.625-in. tricone bit to 926 ft bgs. The next day, Schlumberger again attempted to lower the first geophysical logging tool past 540 ft bgs but failed because of the obstruction. To ensure clear passage through the borehole for geophysical logging tools and subsequent well installation, Dynatec installed 9.625-in. drill casing to 599 ft bgs and then reamed the borehole again with a 7.5-in. mill-tooth bit to 926 ft bgs.

Geophysical logging was successfully conducted on September 23 and 24, 2002; however, slough had partially filled the bottom portion of the borehole from 812 to 926 ft bgs. Dynatec again reamed the borehole with a 7.5-in. mill-tooth bit to 926 ft bgs, and resumed open hole drilling to 935 ft bgs. On September 25, 2002, an attempt was made to install the 5-in. stainless steel well casing and screens, but the borehole had sloughed in to 820 ft. As a result of the sloughing, the well screens could not be set at the designed depths. The stainless steel casing was tripped out of the borehole and drilling operations resumed to advance the 9.625-in. drill casing to the depth required for well installation. Dynatec tripped in a 10.75-in. UR-DTH hammer bit and advanced additional 9.625-in. drill casing from 599 to 887 ft bgs on September 26, 2002. Drilling operations then ceased, and the well was installed.

4.0 SAMPLING AND ANALYSIS OF DRILL CUTTINGS AND GROUNDWATER

Drill cuttings were collected at 5-ft intervals as specified in the SAP (LANL 2002, 73390). A portion of the cuttings was sieved (at >#10 and >#35 mesh) and placed in chip tray bins along with an unsieved portion. These samples were used to prepare lithologic logs (Appendix C). The remaining cuttings were placed in ziplock bags and set in core boxes for curation. Prior to curation, 14 sample splits were removed for use in mineralogy, petrography, and geochemical analyses.

One groundwater sample was collected from the open borehole during drilling in a perched zone and analyzed for low-level tritium. In addition, a groundwater sample from the regional aquifer was collected from a 9490-gal. aliquot representing the final 12 hr of well development; the sample was analyzed for select inorganic, radiological, and organic constituents. The results are reported below.

Geochemistry of Sampled Waters

Groundwater samples were analyzed to investigate the presence of constituents resulting from Laboratory activities. Major potential contaminants of concern at R-23 include perchlorate, nitrate, and tritium.

Perched groundwater from 470 ft bgs was collected by reverse circulation through the drill string. Groundwater samples were collected using a submersible pump with the intake at 860 ft bgs (screen interval from 816.0 to 873.2 ft bgs). Nonfiltered water was collected for metals, trace elements, major cations, major anion, organics, and radiochemical analyses. Samples were acidified as needed with the appropriate analytical-grade acid to a pH of 2.0 or less for metal, major cation, and volatile organic compound (VOC) analyses. All groundwater samples collected in the field were stored at 4°C until they were analyzed.

Groundwater samples were analyzed by fixed laboratories under contract to the Laboratory under the University of California Los Alamos National Laboratory statement of work for analytical laboratories (LANL 2000, 71233) and at the Earth and Environmental Science (EES)-6 laboratory using techniques specified in the US Environmental Protection Agency (EPA) SW-846 manual. Ion chromatography (IC) was the analytical method used for bromide, chloride, fluoride, nitrate, nitrite, oxalate, perchlorate, phosphate, and sulfate. Inductively coupled (argon) plasma emission spectroscopy (ICPES) was used for aluminum, arsenic, barium, chromium, cobalt, copper, iron, manganese, nickel, selenium, silver, calcium, magnesium, potassium, silica, sodium, and zinc. Antimony, beryllium, cadmium, lead, thallium, vanadium, and uranium, were analyzed by inductively coupled (argon) plasma mass spectrometry (ICPMS). Tritium activity in a groundwater sample was determined by electrolytic enrichment at the University of Miami. Americium-241 was analyzed according to HASL-300; cesium-137 was analyzed by generic gamma spectroscopy; plutonium-238 and plutonium-239 were analyzed by isotopic plutonium (HASL-300); strontium-90 was analyzed by beta counting; and uranium-234, uranium-235, and uranium-238 were analyzed by isotopic uranium (HASL-300). VOC analysis was performed by gas chromatography mass spectroscopy. The precision limits (analytical error) for major ions and trace elements generally were less than ±10% using ICPES and ICPMS.

Results of screening analyses for regional groundwater samples collected from the Cerros del Rio Basalt and Santa Fe Group in R-23 are provided in Table 4.1-1. Based on analytical results, contamination from Laboratory discharges does not appear to be present in the regional aquifer at this well site.

Table 4.1-1
Hydrochemistry of Perched and Regional Aquifer, Characterization Well R-23

Parameter and Analyte	Cerros del Rio Basalt (perched) (470 ft bgs) 09/19/02	Santa Fe Group (regional) 10/17/02 (816.0–873.2 ft bgs)
Parameter		
Alkalinity (lab; mg $CaCO_3$/L)	—	95.1
Conductivity (field; µS/cm)	—	107
pH (field)	—	7.28
Temperature (field; ^{o}C)	—	18.9
Turbidity (field; NTU)	—	1.37
Inorganic Analyte		
Al (mg/L)	—	0.013
Sb (mg/L	—	[0.001], U
As (mg/L)	—	0.001
Ba (mg/L)	—	0.047
Be (mg/L)	—	[0.001], U
B (mg/L)	—	0.029
Br (mg/L)	—	0.04
Cd (mg/L)	—	[0.001], U
Ca (mg/L)	—	25.1
Cl (mg/L)	—	3.72
ClO_4 (mg/L)	—	[0.004], U
ClO_3 (mg/L)	—	[0.02], U
Cr (mg/L)	—	0.0022
Co (mg/L)	—	0.0012
Cu (mg/L)	—	0.0014
F (mg/L)	—	0.29
Hg (mg/L)	—	[0.0002], U
Fe (mg/L)	—	0.21
Pb (mg/L)	—	[0.001], U
Mg (mg/L)	—	5.33
Mn (mg/L)	—	0.44
Mo (mg/L)	—	0.0031
Ni (mg/L)	—	0.0026
NO_3 (mg/L; as N)	—	0.47
NO_2 (mg/L; as N)	—	[0.006], U
C_2O_4 (mg/L) (oxalate)	—	[0.02], U

Table 4.1-1 (continued)

Parameter and Analyte	Cerros del Rio Basalt (perched) (470 ft bgs) 09/19/02	Santa Fe Group (regional) 10/17/02 (816.0–873.2 ft bgs)
P (mg/L)	—	[0.02], U
K (mg/L)	—	2.75
Se (mg/L)	—	[0.001], U
Ag (mg/L)	—	[0.001], U
Na (mg/L)	—	16.5
SiO_2 (mg/L)	—	66.8
SO_4 (mg/L)	—	11.2
Tl (mg/L)	—	[0.001]' U
U (mg/L)	—	0.0011
V (mg/L)	—	0.005
Zn (mg/L)	—	0.001
Organic Analyte		
Acetone (mg/L)	—	6.4
Bis-2-ethylhexylphthalate	—	2.2, J
Radiochemical Analyte		
Am^{241} (pCi/L)	—	[0.0044], U
Cs^{137} (pCi/L)	—	[0.495], U
^3H (pCi/L)	[25.6], U (< 3TPU)	—
Pu^{238} (pCi/L)	—	[0.0234], U
Pu^{239} (pCi/L)	—	[0.0117], U
Sr^{90} (pCi/L)	—	[0.108], U
U^{234} (pCi/L)	—	0.995
U^{235} (pCi/L)	—	[0.0109], U
U^{238} (pCi/L)	—	0.476

Notes: 1. U = not detected.
2. Dash = “not analyzed.”
3. J = the analyte is classified as “detected” but the reported concentration value is expected to be more uncertain then usual.
4. All groundwater samples are nonfiltered.
5. < 3TUP = less than three times the propagated uncertainty.

5.0 BOREHOLE GEOPHYSICS

The Laboratory and Schlumberger provided geophysical logging services at well R-23; Table 5.0-1 lists borehole and well logging surveys performed.

Table 5.0-1
Borehole and Well Logging Surveys, Characterization Well R-23

Operator	Date	Method	Cased Footage	Open-Hole Interval (ft bgs)	Remarks
WGII/LANL	September 23, 2002	Video, natural gamma	0–599	599–826.6, 599–840	LANL borehole logging conducted in borehole prior to design and installation of the well casing.
Schlumberger	September 24, 2002	Logging suite[a,b]	0–599	599–828	Schlumberger borehole logging conducted in borehole prior to design and installation of the well casing.
WGII/LANL	November 21, 2002	Video, natural gamma	0–886	NA[c]	Video run to document and verify well screen interval and interior condition of the well. Natural gamma was run to verify backfill placement.

[a] Schlumberger's suite of borehole logging survey tools included array induction, combinable magnetic resonance, triple detector lithodensity, elemental capture, natural gamma ray spectroscopy, thermal\epithermal compensated neutron, and natural gamma.

[b] Array induction and combinable magnetic resonance logs were run only in the open portion of the borehole.

[c] NA = Not applicable; video and natural gamma logs were run inside the well casing.

5.1 Geophysical Logging Using Laboratory Tools

On September 23 and November 21, 2002, WGII ran natural gamma and video logs in borehole R-23 using down-hole tools provided by the Laboratory (Table 5.0-1). Natural gamma logs have proven successful in discriminating between geologic units that contain varying concentrations of uranium, thorium, and potassium. The first natural gamma log was run to provide lithologic and stratigraphic information that would complement data gathered from cuttings. The second natural gamma log was run to verify placement of annular fill materials after well R-23 was installed. The first gamma log was run with 18-in. surface casing in place from the surface to 37 ft bgs, 11.75-in. drill casing from the surface to 277 ft bgs, the 9.625-in. drill casing from ground surface to 599 ft bgs, and the open borehole from 599 to 840 ft bgs. The second gamma log was run inside the installed well casing, with the 18-in. surface casing in place from the surface to 37 ft bgs. Measurements of natural gamma activity were obtained every 0.1 ft as the logging tool was raised in the hole at a rate of about 15 ft/min.

The first video log was run to evaluate the stability of the borehole wall before the natural gamma tool was deployed and to record stratigraphic, geologic, and hydrologic features visible in the open portion of the borehole. The second video log was run as a quality control procedure to document well installation and inspect the condition of casing and screen after well development. The open-borehole video logs are included in this report as Appendix D (on CD attached to the inside back cover).

5.2 Schlumberger Geophysical Logging

Schlumberger conducted borehole geophysical logging on September 24, 2002, in the R-23 borehole (Table 5.0-1). A suite of logs was collected prior to well design and installation. The Schlumberger geophysical logging suite was collected with 18-in. surface casing in place from the surface to 37 ft bgs, 11.75-in. drill casing from ground surface to 277 ft bgs, and 9.625-in. drill casing from surface to 599 ft bgs. The borehole was open from 599 to 828 ft bgs.

Geophysical logging was conducted to characterize conditions in hydrogeologic units penetrated by the borehole, with an emphasis on determining moisture distribution in the vadose zone and saturated porosity in the regional aquifer and obtaining lithologic/stratigraphic data, including evaluating borehole geometry and the amount of drilling-fluid invasion along the borehole wall.

The Schlumberger suite of geophysical logging tools included the following:

- Array Induction Tool, Version H (AITH™) measures formation electrical resistivity and borehole fluid resistivity, evaluates the drilling fluid invasion into the formation, and determines the presence of moist zones far from the borehole wall.
- Combinable Magnetic Resonance (CMR™) measures nuclear magnetic resonance response of the formation, for evaluating total and effective water-filled porosity of shallow formations and estimating pore size distribution and hydraulic conductivity of saturated intervals.
- Triple detector LithoDensity (TLD™) measures formation total porosity and bulk density, photoelectric effects, and borehole diameter and assists in characterizing lithology.
- Thermal/Epithermal Compensated Neutron Tool, Model G (CNTG™) measures volumetric water content beyond the casing to evaluate formation moisture content and porosity.
- Elemental Capture Sonde (ECS™) measures elemental weight concentrations of a variety of elements (Ca, Fe,) to aid in characterizing the formation mineralogy, lithology, and water content.

In addition, a calibrated natural-gamma logging tool was used to record gross natural gamma ray activity with every logging method to correlate depth runs between each survey.

The Schlumberger logging summary report and montage files for borehole R-23 are presented as Appendix E (on a CD attached to the back inside cover of this report).

6.0 LITHOLOGY AND HYDROGEOLOGY

A preliminary assessment of the hydrogeologic features encountered during drilling is presented below, including a description of the geologic formations and units identified during characterization of cuttings. Discussion of groundwater occurrence is based on evidence gathered during drilling, open-hole logging, and geophysical logging.

6.1 Stratigraphy and Lithologic Logging

Rock units and stratigraphic relationships, interpreted primarily from visual examination of drill cuttings samples and supporting geophysical data, are discussed in order of younger-to-older occurrence. Such interpretations may be refined upon further analysis of petrographic, geochemical, and mineralogical analyses as well as geophysical logging data. A field-generated lithologic log for R-23 is presented as Appendix C.

Alluvium (0 to 10 ft bgs)

Unconsolidated tuffaceous sands and gravels were noted in the interval from 0 to 10 ft bgs. Alluvial sediments consist primarily of detrital clasts of Bandelier Tuff and Tschicoma dacitic lavas, with mineral grains consisting predominantly of quartz and feldspar. The alluvium is part of the inactive stream channel of Pajarito Canyon.

Bandelier Tuff (10 to 36 ft bgs)

The Quaternary-age Bandelier Tuff was encountered in the interval from 10 to 36 ft bgs. Only the lower two subunits of the Bandelier tuff are locally represented: the Otowi Member and the Guaje Pumice Bed.

Otowi Member of the Bandelier Tuff (10 to 30 ft bgs)

The Otowi Member of the Bandelier Tuff is made up of rhyolitic ash-flow tuffs that contain ash, vitric pumice with quartz and sanidine phenocrysts, and volcanic lithics of intermediate composition (i.e., dacite and andesite). The Otowi ash-flow tuffs are nonwelded at the R-23 site.

Guaje Pumice Bed (30 to 36 ft bgs)

The Guaje Pumice Bed is a fall deposit composed of layered rhyolitic pumice and ash that regionally forms the basal unit of the Bandelier Tuff. Drill cuttings from this interval are composed of frothy-textured pumice; finer ash was washed out during drilling.

Cerros del Rio Basalt (36 to 795 ft bgs)

The Pliocene Cerros del Rio basalt is a sequence of mafic volcanic lavas, breccias, and pyroclastic strata (Dethier 1997, 49843). At R-23, borehole drilling penetrated 759 ft of lavas and interflow sedimentary deposits in the interval from 36 to 795 ft bgs.

Cuttings samples indicate that the upper half of the Cerros del Rio basalt section, from 36 to 411 ft bgs, is made up of a series of basaltic flows separated by layers of scoriaceous breccia. At least four separate lava flows are present in this interval. Flow units in the interval from 36 to 168 ft bgs are slightly porphyritic with sparse olivine and plagioclase phenocrysts in an aphanitic groundmass. Five- to ten-ft-thick layers of oxidized scoriaceous basalt mark the bases of some flows. At least two additional flows are evident in the interval from 168 to 411 ft bgs. These are massive, slightly porphyritic, olivine- and pyroxene-bearing basalts that are separated by intervals of basaltic scoria. Basalts of the upper lava flows have weak alteration in the form of iron oxidation and local clay development on fractures. Generally more intense rock alteration, characterized by calcite precipitation and groundmass alteration, is observed in cuttings of the lower flows.

The interval from 411 to 531 ft bgs represents a sequence of basaltic lavas and interflow sedimentary deposits. Chip samples from throughout this section typically contain slightly porphyritic, olivine-bearing basalt and locally abundant fragments of siltstone and claystone. A discrete basalt lava flow is indicated by a coherent 20-ft-thick interval at the base of this section.

The Cerros del Rio basalt is represented by lavas and volcaniclastic interflow sediments from 531 to 696 ft bgs, with underlying basalt lavas at the base of this interval from 696 to 795 ft bgs. Clayey sand and gravel deposits in the upper 165 ft (531 to 696 ft bgs) of this section are represented by abundant clastic sedimentary rock fragments, including basaltic sandstone, tuffaceous sandstone, siltstone, and claystone. A significant component of altered basalt chips is present throughout the interval. One or more strongly altered basalt flows make up the lowermost part of the Cerros del Rio basalt section from 696 to 795 ft bgs. The upper part of this interval is highly vesicular to scoriaceous, with vesicles that commonly are lined with silica and clay. The lower part consists of massive olivine- and pyroxene-bearing basalts with groundmass that is pervasively altered and bleached; probable fracture faces have pitted surfaces.

Unassigned Sediments with Basalt Detritus (795 to 821 ft bgs)

The interval from 795 to 821 ft bgs is interpreted as a sedimentary unit containing abundant basaltic detritus, probably derived from Cerros del Rio sources, plus sands that include microcline and quartz. This deposit may represent either a local Puye Formation subfacies or Santa Fe Group sediments reworked with early Cerros del Rio debris, but these sediments but are unassigned, pending further study and determination of the degree of cuttings intermixture during drilling.

Santa Fe Group Sediments (821 to 935 ft bgs)

Santa Fe Group sediments, composed of volcanic and quartzo-feldspathic sand and gravel deposits, were encountered from 821 ft bgs to the bottom of the borehole, at 935 ft bgs (TD). Chip samples of this unit are composed of basalt and minor dacite together with abundant detrital quartzite, feldspar (microcline), and granitic lithics derived from Precambrian sources. The relative abundance of Precambrian versus volcanic constituents increases downward in the interval, possibly as a result of lessening contamination of deeper sands by chips of overlying Cerros del Rio basalts that were carried down during drilling.

6.2 Groundwater Occurrence and Characteristics

It was anticipated that the regional water table would be encountered at approximately 892 ft bgs, in the Cerros del Rio basalt formation. Perched saturated zones were considered likely, although no specific depths were presented in the SAP (LANL 2002, 73390). Drilling throughout the entire depth of the borehole below 92 ft bgs used air-rotary casing-advance techniques with and without foam additives. This method substantially reduces the ability to detect and observe perched groundwater zones, if they were present. However, a sample of possible perched groundwater at approximately 470 ft bgs was collected and analyzed for anions, metals, and low-level tritium.

The first water level measurement for the regional zone of saturation was obtained on September 19, 2002, after the borehole was drilled to 926 ft bgs and had rested for approximately 4 hr. The regional water table was measured at 817.5 ft bgs, in basaltic sediment between the Cerros del Rio basalt and underlying Santa Fe Group sediment. Drill casing (11.75-in.) was in place to 277 ft bgs at that time. After well construction but before well development, the water level was measured at 828.3 ft bgs. At the end of well development, the water level in the well stabilized at 829 ft bgs.

7.0 WELL DESIGN AND CONSTRUCTION

Sections 7.1 and 7.2 describe the well R-23 design and construction, respectively.

7.1 Well Design

The design for well R-23 was completed jointly by the Laboratory and WGII, in consultation with the US Department of Energy and the New Mexico Environment Department (NMED). Information gathered from geophysical logs, video logs, borehole geologic samples, water-level data, field water-quality data, and drillers' observations was analyzed by the Groundwater Integration Team to plan the well design. The final design specified a single screen that straddled the water table (measured at 817.5 ft bgs on September 19, 2002) would be equipped with a dedicated pump. This well design permits monitoring water levels and sampling for potential contaminant concentrations in the regional aquifer downgradient of Laboratory operations. An intermediate perched zone at 470 ft may exist, but the SAP had called for installing a single screen in the regional aquifer. Planned and actual screen locations are given in Table 7.1-1.

Table 7.1-1
Summary of Well Screen Information, Characterization Well R-23

Screen	Planned Depth (ft)	Actual Depth (ft)	Geologic/Hydrologic Setting
1	816.9–873.9	816.0–873.2	Top of regional aquifer in basaltic sediments and in the Santa Fe Group sediments

7.2 Well Construction

Well R-23 casing and pipe-based screens were manufactured using 4.5-in. inner diameter (ID)/5.0-in. outer diameter (OD), type 304 stainless steel fabricated to American Society for Testing and Materials (ASTM) standard A554. External couplings were type 304 stainless steel, fabricated to ASTM standards A312 and A511, both of which exceed the tensile strength of the threaded casing ends. The pipe-based screens were modified from 10-ft sections of blank well casing by drilling 0.5-in.-diameter holes (168 holes/ft) and then welding a stainless steel wire-wrap (with 0.010-in. spacing) over the perforated interval. The final OD of the screened section was 5.56 in.

All stainless steel well components were cleaned at the well site using a high-pressure steam cleaner and scrub brushes. All annular fill materials were placed in the well casing/borehole annulus through a tremie pipe. Well-construction activities were completed from September 24 to October 2, 2002.

7.2.1 Well Steel Installation

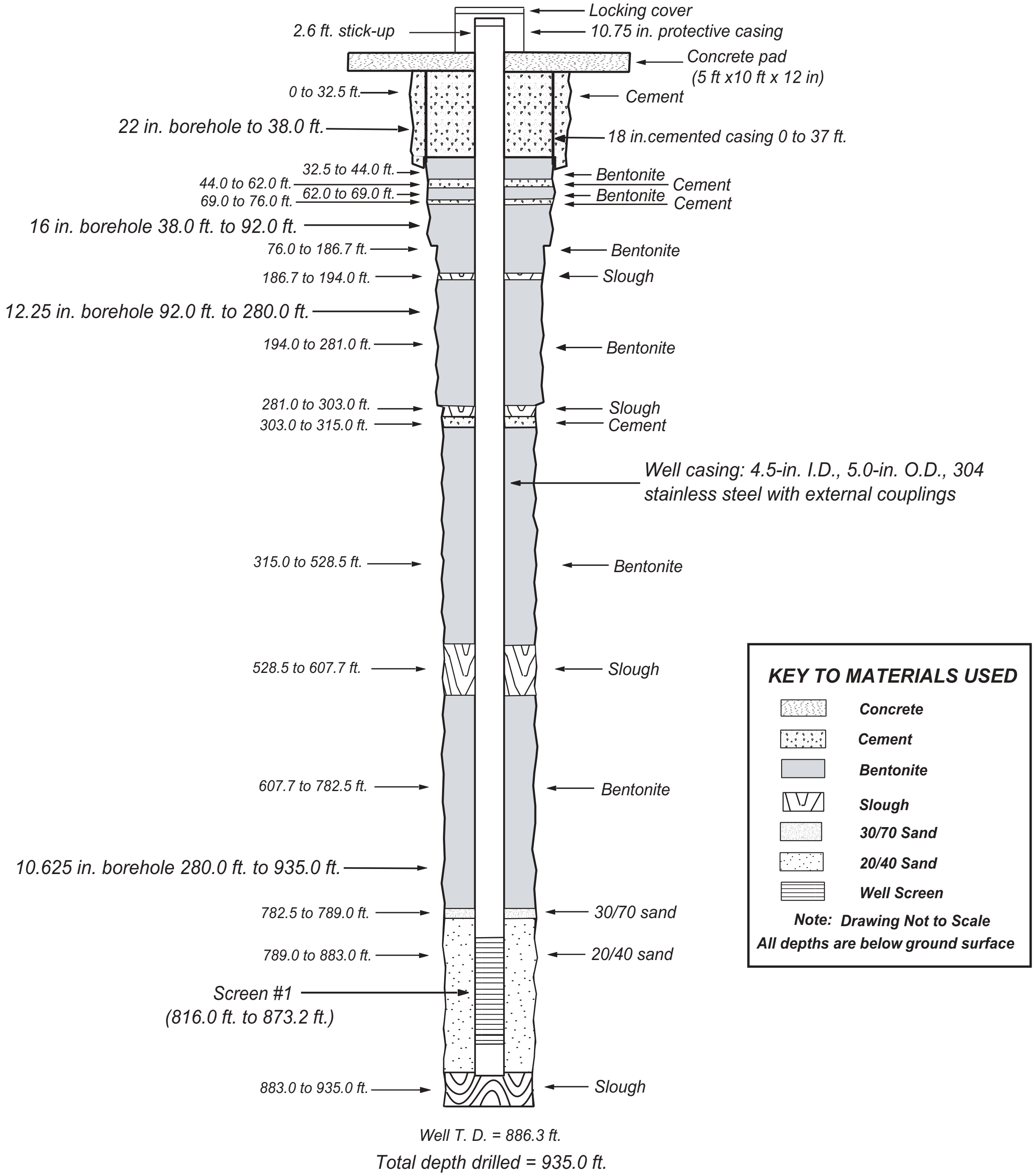
Well installation consisted of connecting joints of stainless steel well casing and screen sections using threaded couplings. Stainless steel centralizers were not installed because the 9.625-in. drill casing (temporarily left in the hole to ensure borehole stability during well installation) limited available space.

Dynatec initially installed approximately 830 ft of the R-23 well casing and screen on September 24, 2002. However, due to sloughed material in the well annulus, Dynatec could not advance the well casing to the planned designed depth of 887 ft. Tremie pipe was lowered in the annulus to a depth of 835 ft bgs, and a solution of water and EZ MUD® polymer was then pumped into the annulus in an attempt to clear the slough and lower the well casing to the desired depth. Air pressure also was applied at depth but the well casing still could not be advanced. The tremie pipe and well casing then were removed from the borehole.

Dynatec made a second attempt to install the well by advancing the 9.625-in. casing to 887 ft. The drill-bit assembly was tripped out and the tremie rod tripped in to begin well construction. On September 27 and 28, 2002, Dynatec installed the well casing and screen sections. The well casing was successfully lowered to a depth of 882.8 ft bgs. Dynatec advanced the well string an additional 2.5 ft, using a water and EZ MUD® polymer solution to wash slough material out of the bottom of the borehole. The bottom of the well casing was set at 886.3 ft bgs. Figure 7.2-1 shows the as-built well casing configuration and the depths of the various well components from ground surface.

7.2.2 Annular Fill Placement

A steel tremie pipe was used to deliver annular materials to the specified depths (Figure 7.2-1). The bottom of the borehole was measured at 883.0 ft bgs as placement of backfill materials began. The 11.75-in. and 9.625-in. drill casings were retracted as fill materials were placed in the annulus. Filter pack across the screened interval consisted of silica/sand materials mixed with municipal water and placed in the annulus. Bentonite materials were placed above the screened interval to seal the annular space and isolate the screened zone. Above the silica/sand fill, bentonite mixed with EZ-MUD® polymer and municipal water was delivered to the annulus. Portland® cement (mixed at a ratio of 5 gal. of water to each bag of cement) was used to provide a foundation for the annular fill above the regional aquifer and to protect the annular space around the wellhead in the upper 32.5 ft of the borehole. Approximately 9860 gal. of municipal water was used during placement of annular fill material.



Note:
1. The screen interval lists the footage of the pipe perforations, not the top and bottom of screen joints.
2. Pipe-based screen: 4.5-in. I.D., 5.563-in. O.D., 304 stainless steel with s.s. wire wrap; 0.010-in slot.
3. The upper intervals of slough consist of basaltic gravels; slough at the base of the borehole consists of Santa Fe Group sands.
4. Centralizers not placed due to use of 9-5/8" casing for borehole stability.
5. Dedicated pump location not shown.
6. Well sump interval: 873.2 to 886.3 ft.

Figure 7.2-1. As-built configuration diagram, characterization well R-23

Dynatec conducted annular fill activities from September 28 through October 2, 2002. Table 7.2-1 shows the annular fill materials installed. Figure 7.2-1 shows the final configuration of annular materials.

Table 7.2-1
Annular Fill Materials Used, Characterization Well R-23

Material	Use/Function	Amount	Unit*
20/40 sand (medium-grained)	To pack screened intervals	71	Bag
30/70 sand (fine grained)	To separate screen packs from bentonite or cement from bentonite	6	Bag
Benseal® bentonite (granular bentonite)	Produces slurry when mixed with water	125	Bag
Holeplug® (0.375-in. angular and unrefined bentonite chips)	To provide a borehole annular seal	356	Bag
Pelplug® bentonite pellets (0.25-in. by 0.375-in. refined elliptical pellets)	To provide borehole annular seal below water table	357	Bucket
Portland® cement (mixed with municipal water at ratio of 5 gal. water for each bag of cement)	To provide annular support and surface seal on upper 100 ft of borehole	57	Bag

*Sand bag = 50 lb ea; bentonite bag/bucket = 50 lb ea; cement bag = 94 lb ea.

8.0 WELL DEVELOPMENT AND HYDROLOGIC TESTING

Well development activities at well R-23 were conducted from October 8 to 17, 2002. Hydrologic tests were not conducted.

8.1 Well Development

Well development at R-23 was performed using a variety of methods: wire-brushing the well interior, surging to draw fine sediment from the constructed filter pack, and bailing to remove solid materials from the well. In addition, the well was pumped to remove remaining fines from the filter pack and adjacent formation.

Adequacy of well development was based on field water-quality parameters (turbidity, pH, specific conductance, and temperature). To monitor progress of each method of development, groundwater samples were collected approximately every hour and the parameters were measured. One goal of well development was to remove suspended sediment from the water until turbidity had stabilized to a value less than 5 nephelometric turbidity units (NTUs) for three consecutive samples. Similarly, other measured parameters were required to stabilize before well development could be terminated. The well was declared sufficiently developed when the above criteria were met or could not be improved with continued pumping. Table 8.1-1 presents pumping and water-quality parameter data measured at the beginning and end of each well-development method.

Preliminary bailing of the well sump and screen was performed on October 8, 2002. The casing and screen then were cleaned using a wire-brush system to remove any materials that may have been introduced to the well interior during construction. Surging techniques were used across the screen with a weighted surge block to induce rapid upward-downward strokes. The well screen was surged repeatedly; periods of bailing followed from October 10 to 12, 2002. During this development method, early water turbidity measurements exceeded 1000 NTU and declined to 522 NTU after an estimated 3800 gal. were bailed (Table 8.1-1).

Table 8.1-1
Development of Characterization Well R-23

Method	Water Produced (gal.)	Range of Parameters[a]			
		pH	Temperature (°C)	Specific Conductance (µS/cm)[b]	Turbidity (NTU)
Preliminary bailing/wire brushing/surging	3800	7.5–7.4	20.3–21.1	241–160	>1000–522
Pump	22,100	7.3–7.3	20.7–18.9	192–107	16–1.4
Install dedicated submersible pump	ND[c]	ND	ND	ND	ND
Test submersible/final pumping	5970	7.96–8.44	19.5–18.2	208–167	2.3–1.4
TOTAL	31,870				

[a] Parameters presented as value at beginning followed by value at end of development method.

[b] Specific conductance reported in microsiemens per centimeter (µS/cm).

[c] No data.

Pump development of R-23 was conducted from October 15 to 17, 2002. A 7.5-horsepower (hp) submersible pump was lowered to 860 ft bgs, near the bottom of the screen. On/off cyclic pumping was conducted with approximately 30-min periods of nonpumping to allow water levels in the well to recover. Field parameters were monitored in collected water samples. During pump development turbidity declined from an initial value of 16 to 1.4 NTU (Table 8.1-1) after an estimated 22,200 gal. were purged. Figure 8.1-1 shows the effects of pumping on measured field parameters. The graph shows that pH, specific conductance, and temperature were stable during the later stages of pumping and that turbidity declined consistently to a value less than 5 NTU when R-23 was declared fully developed.

8.2 Hydrologic Testing

No hydrologic tests were performed. The Laboratory plans to conduct hydrologic tests at a later date and to present the results in a separate report.

8.3 Dedicated Pump Installation

On January 6, 2003, a dedicated pump for groundwater sampling was installed in well R-23. The pump is a 4-in.-diameter Grundfos Model 10S50-48DS with a 5 hp, 460-V, three-phase motor. With the pump intake set at 871 ft bgs, the pump is capable of producing groundwater at a rate of 10 gal./min. The pump will be used to purge and collect groundwater samples for water-quality monitoring. The dedicated pump assembly, riser pipe, and other components were installed with a Smeal work-over rig provided and operated by Rio Grande Well Supply from Albuquerque, New Mexico.

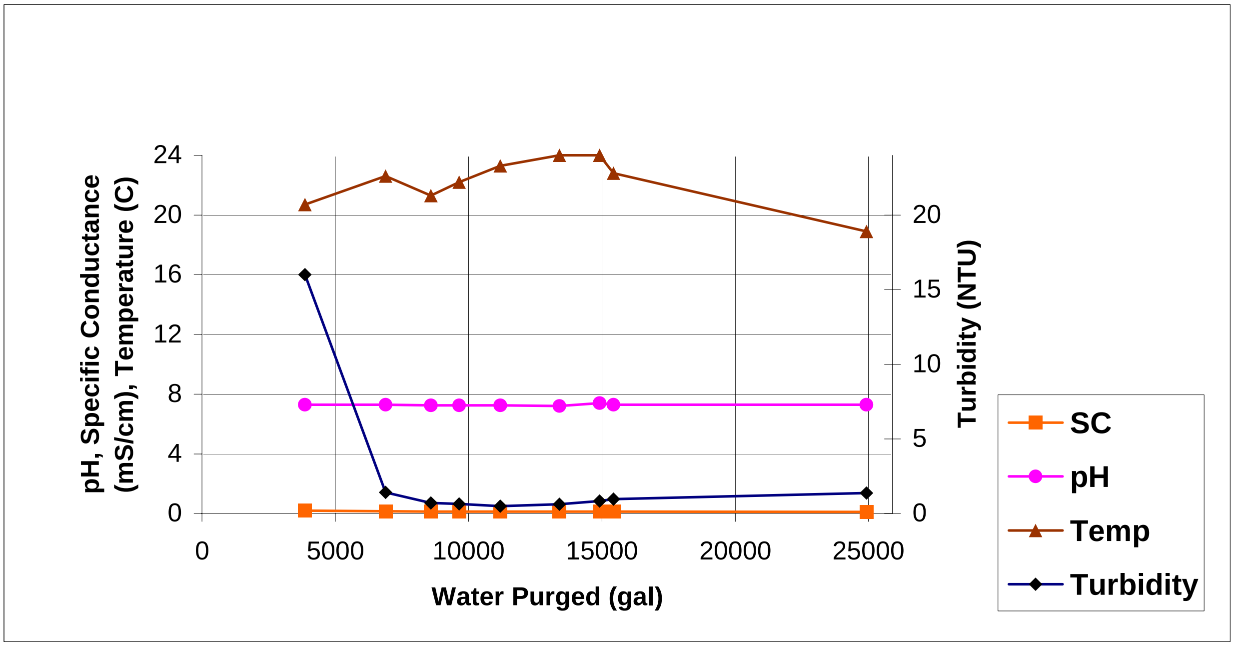


Figure 8.1-1. Effects of pump development on water quality parameters, characterization well R-23

The riser pipe consisted of 1.25-in., Schedule 40S, type 304/TP 304L stainless steel connected with 3000-lb test F304/F304L stainless steel couplers. The thread compound used was Loctite 567. A 1-in., Schedule 40, polyvinyl chloride (PVC) flush-thread transducer access pipe was set at the top of the pump to permit unobstructed access for water-level measurements. The pump control leads and PVC transducer pipe were secured to the riser pipe with a stainless steel band 5 ft above the pump and every 60 ft thereafter. In addition, the leads and PVC pipe were secured to the riser pipe every 10 ft with cold-weather vinyl cable and pipe tape that is both water- and corrosion-resistant. The length of the pump assembly, riser joints, and couplers were measured and assembled to ensure installation of the pump intake at 871 ft. bgs.

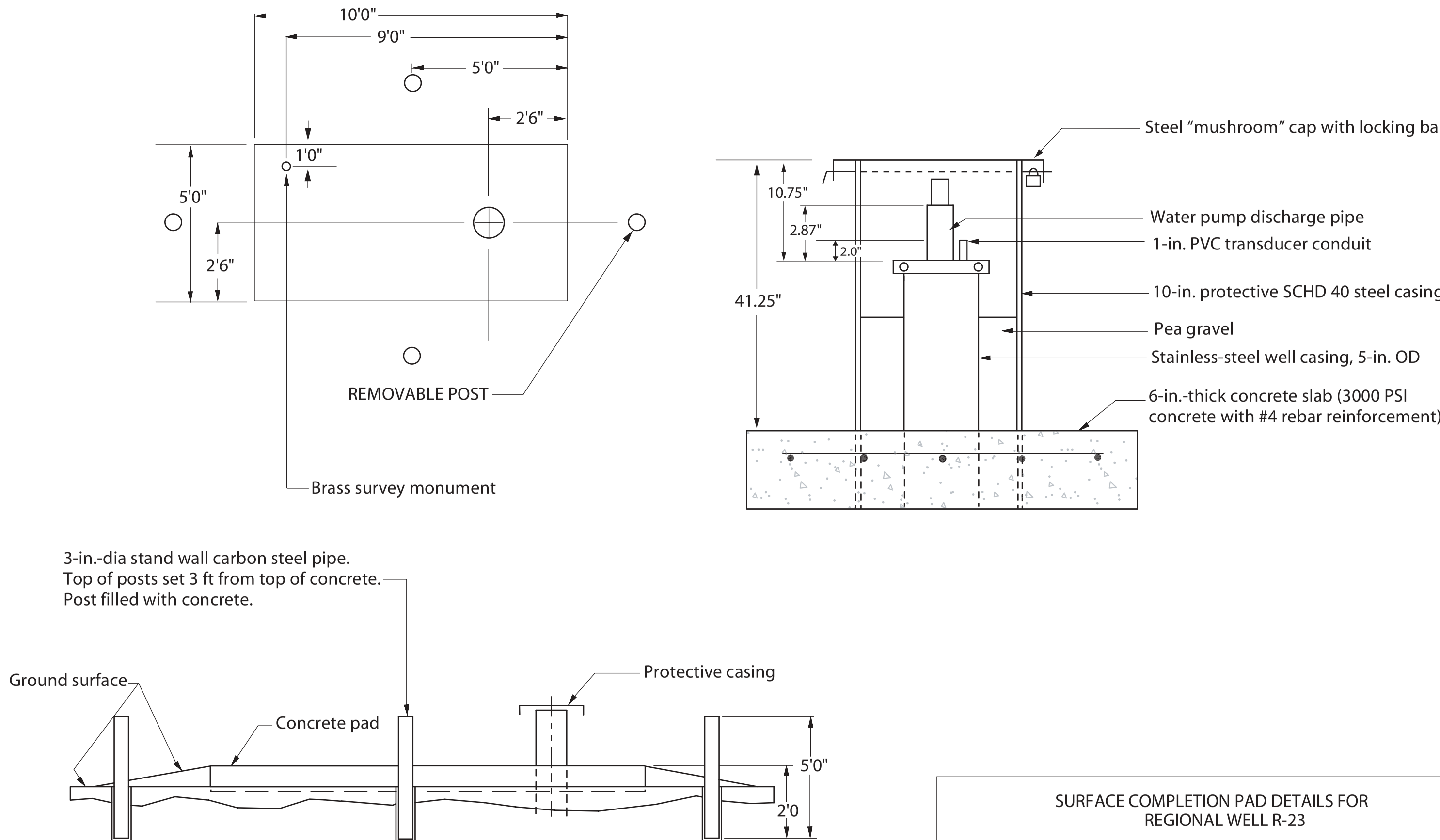
The pump installation was completed on January 8, 2003. The dedicated pump was tested on February 19 and 20, 2003. A total of 5970 gal. of groundwater were produced from the well during this test. Final turbidity readings were less than 2 NTU.

9.0 WELLHEAD COMPLETION AND SITE RESTORATION

After pump installation, finish work commenced on the wellhead area. Well components were surveyed, and the site underwent final cleanup and restoration.

9.1 Wellhead Completion

Surface completion for well R-23 involved constructing a reinforced (3000 pounds per square inch [psi]) concrete pad, 5-ft wide by 10-ft long by 6-in. thick, around the well casing to ensure long-term structural integrity (Figure 9.1-1). The concrete pad was poured on November 26, 2002. A brass survey cap was installed in the northwest corner of the concrete pad. A 10.75-in. steel casing with locking lid was installed to protect the well riser. The pad was designed to be slightly elevated, with base-course gravel graded around the pad to promote drainage. Four 4-in.-diameter cement-filled steel bollards were placed around the well pad, one on each side. One bollard is removable to allow access for sampling and maintenance.



NOTES:

1. Los Alamos National Laboratory brass monument coordinates: E 1647914, N 1755165, el. 6527.8.
2. Grundfos™ Model 10S50-48DS, 5 hp, 460-volt pump and motor installed.
3. Pump intake set at 870.7 ft bgs.
4. 1.25-in. Schedule 40S, type 304, stainless-steel riser pipe installed.
5. Not to scale.

SURFACE COMPLETION PAD DETAILS FOR REGIONAL WELL R-23	
WGII DWG. ERP001 REV.002	
Rev. 0 Designed by: Dana Williams 08/15/2001	
Rev. 2 Drawn by: Kevin Sagez 11/05/2002	
Checked by:	
Approvals	Signature/Date
WGII ER Construction Manager	
WGII ER Project Quality Manager	
LANL Representative	

Figure 9.1-1. Surface completion configuration diagram, characterization well R-23

9.2 Geodetic Survey

Southwest Mountain Surveys, Inc. (NMPLS #6998), conducted a geodetic survey of well R-23 on December 19, 2002, using a global positioning satellite (GPS) system. The GPS system utilizes National Geodetic Vertical Datum (NGVD99/96) for vertical computations; the datum for the horizontal control network is North American Datum 1983 (NAD 83). The survey located the brass monument in the northwest corner of the concrete pad and measured location and elevation at the top of the steel protective casing and the top of the stainless steel well casing (Table 9.2-1). The coordinates shown are in New Mexico State Plane coordinates, Central Zone (NAD 83) expressed in feet. To be consistent with current Laboratory standards, elevations are expressed in feet above mean sea level and referenced to the National Geodetic Vertical Datum of 1929 (NGVD29).

Table 9.2-1
Geodetic Data, Characterization Well R-23

Description	East	North	Elevation
Brass cap in R-23 pad	1647913.60	1755165.37	6527.75
Top of stainless steel well casing	1647918.78	1755161.40	6530.31
Top of protective steel surface casing	1647918.59	1755161.32	6530.70

9.3 Site Restoration

Site restoration activities at R-23 were conducted from February 10 to March 13, 2003 (Figure 3.0-2). Waste-management activities were conducted before and during restoration. Waste materials were removed from the site, as specified in the WCSF. Drilling-generated media, including drilling fluids, cuttings, and development water, were sampled for contaminant analysis. These data were reviewed by the Laboratory and NMED. The drill cuttings then were used to help backfill the cuttings-containment area; drilling fluids and development water were applied to land downgradient of the site and to the road, as specified in the provisions of the Notice of Intent. The waste streams from spill cleanup included petroleum-contaminated soils and absorbent materials that had been used to clean up minor spills. After the Laboratory approved the waste profile forms, the waste streams were disposed of as New Mexico Special Waste. The drill site area was regraded by K. R. Swerdfeger Construction, Inc. Before the area was regraded, the cuttings-containment area was excavated and the plastic lining was removed. The containment basin and water-tank storage areas then were backfilled with dirt that had been bermed during pad construction and the area was regraded. Base-course gravel was regraded and compacted across the site to form a smaller pad. In addition, a chipper was moved to the site to chip slash piles accumulated during tree removal procedures related to drill-pad construction. The slash-pile chips were used to mulch re-seeded areas of the site. The site was re-seeded with a blend of native grasses mixed with fertilizer to facilitate regrowth of ground cover.

10.0 DEVIATIONS FROM THE R-23 SAP

Appendix A compares the actual characterization activities performed at well R-23 with the activities planned in the hydrogeologic work plan and the R-23 sampling and analysis plan (LANL 1998, 59599; LANL 2002, 73390). Significant deviations are discussed below:

- *Planned depth.* Well R-23 was planned for a depth of 1392 ft (LANL 2002, 73390). This depth was based on the general characterization goals of the hydrogeologic work plan to investigate the hydrogeology in the upper 500 ft of the regional zone of saturation. Drilling operations were terminated at R-23 because hole stability problems raised concerns about loss of the borehole and because site-specific objectives for deep drilling had been accomplished. The goals for R-23 were attained by drilling to 935 ft, a depth at which the borehole was deep enough to install a single-screen well and penetrate the base of the Cerros del Rio basalt.
- *Amount of core.* Core was not collected at R-23 because the site finally chosen had only a thin cover above the Cerros del Rio lavas. The lavas would have provided poor samples for contaminant characterization because of the likelihood of focused fracture rather than dispersed matrix flow paths.
- *Number of water samples collected for contaminant analysis.* One sample was collected and analyzed from perched water at 470 ft bgs. One sample was collected from the regional aquifer at the end of well development and submitted for analysis.
- *Number of core/cuttings samples collected for contaminant analysis.* No core was collected for the reasons cited above. Cuttings were not selected for contaminant analysis because of the unlikely detection of contaminants from basalt matrix chips, when contaminant accumulation would most likely occur along fractures.
- *Core/cuttings sample analytes.* No core was collected; no analyses were performed on cuttings for the reasons cited above.

11.0 ACKNOWLEDGEMENTS

Dynatec Drilling Company provided rotary drilling services.

Tetra-Tech EM, Inc.; D. B. Stephens and Associates, Inc.; and S. M. Stoller provided support for well-site geology, sample collection, and hydrologic testing.

Southwest Mountain Surveys provided the final geodetic survey of finished well components (NMPLS #6998).

D. Thompson and C. Schultz of PMC Technologies (Exton, Pennsylvania); and P. Schuh, E. Tow, and R. Lawrence of Tetra-Tech EM, Inc. (Albuquerque, New Mexico), contributed to the preparation of this report.

R. Bohn and E. Louderbough of Los Alamos National Laboratory reviewed this report for classification and legal purposes, respectively.

D. Broxton, A. Groffman, S. Pearson, W. Stone, and D. Vaniman of Los Alamos National Laboratory prepared this report.

Schlumberger Integrated Water Solutions provided processing and interpretation of borehole geophysical data.

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Appendix A

Activities Planned for R-23 Compared with Work Performed

Activity	"Hydrogeologic Workplan" (LANL 1998, 59599)	R-23 Sampling and Analysis Plan (LANL 2002, 73390)	R-23 Actual Work
Planned Depth	100 to 500 ft into the regional aquifer	Estimated depth of 1392 ft below ground surface (bgs)	Total drill depth 935 ft bgs
Drilling Method	Methods may include, but are not limited to hollow stem auger (HSA), air-rotary/Odex/Stratex, air-rotary/Barber rig, and mud-rotary drilling	Drilling methods not specified in SAP.	Fluid-assist air rotary and fluid-assist air rotary with casing advance
Amount of Core	10% of the borehole	Continuous core from surface to estimated depth of 94 ft bgs, but no deeper than 100 ft bgs	No core collected
Lithologic Log	Log to be prepared from core, cuttings, and drilling performance data	Log to be prepared from core, cuttings, geophysical logs and drilling performance data	Log prepared from core, cuttings, geophysical logs and drilling performance data
Number of Water Samples Collected for Contaminant Analysis	A water sample may be collected from each saturated zone, five zones assumed. The number of sampling events after well completion is not specified	If perched water is encountered within the unsaturated zone, one groundwater-screening sample each will be collected within up to three perched zones. Groundwater-screening samples will be collected within the regional aquifer at the regional water table and at the total depth (TD) of the borehole.	One water sample from 470 ft bgs obtained during drilling. Regional aquifer to be sampled in the completed well.
Water Sample Analysis	Initial sampling: radiochemistry I, II, and III, tritium, general inorganics, stable isotopes, volatile organic compounds (VOCs), and metals. Saturated zones: radionuclides (tritium, ^{90}Sr, ^{137}Cs, ^{241}Am, plutonium isotopes, uranium isotopes, gamma spectrometry, and gross alpha, beta, and gamma), stable isotopes (hydrogen, oxygen, and in special cases nitrogen), major ions (cations and anions), trace metals, and trace elements.	Metals (dissolved), Anions (dissolved), VOCs, ^{99}Tc, gamma spec, ^{241}Am, ^{137}Cs, ^{238}Pu, ^{239,240}Pu, ^{234}U, ^{235}U, ^{238}U, ^{90}Sr, stable isotopes (^{18}O/^{16}O, D/H, ^{15}N/^{14}N), tritium (low level or direct counting), RV (Rad Van) gross-alpha, beta, gamma	A possible perched zone was encountered at 470 ft bgs and one groundwater sample was analyzed for metals (including uranium), anions, and low level tritium.
Water Sample Field Measurements	Alkalinity, pH, specific conductance, temperature, turbidity	Alkalinity, pH, specific conductance, temperature, turbidity	pH, specific conductance, temperature, turbidity

Activity	"Hydrogeologic Workplan" (LANL 1998, 59599)	R-23 Sampling and Analysis Plan (LANL 2002, 73390)	R-23 Actual Work
Number of Core/Cuttings Samples Collected for Contaminant Analysis	Twenty samples of core or cuttings to be analyzed for potential contaminant identification in each borehole.	If possible, at least two core/cuttings samples will be collected for geochemical and contaminant characterization within water-bearing zones encountered during drilling.	No cuttings samples submitted for analysis
Core/Cuttings Sample Analytes	Uppermost core or cuttings sample to be analyzed for a full range of compounds: deeper samples will be analyzed for the presence of radiochemistry I, II, and III analytes, tritium (low and high detection levels), and metals. Four samples to be analyzed for VOCs.	Analytical suite for cuttings samples includes anions, stable isotopes, VOCs, tritium profiles, perchlorate, ^{241}Am, ^{238}Pu, ^{239,240}Pu, ^{234}U, ^{235}U, ^{238}U, ^{90}Sr, gamma spectroscopy, radiological screening (gross alpha, beta, and gamma), radionuclides, and metals.	No analyses were performed
Laboratory Hydraulic-Property Tests	Physical properties analyses will be conducted on 5 core samples and will typically include moisture content, porosity, particle density, bulk density, saturated hydraulic conductivity, and water retention characteristics.	Physical properties analyses will be conducted on core samples for moisture content.	No core collected
Geology	Ten samples of core or cuttings will be collected for petrographic, x-ray fluorescence (XRF) and x-ray diffraction (XRD) analyses.	Analytical testing of samples may include mineralogy by XRD, petrography by modal analysis of thin sections, by electron microprobe, and/or by scanning electron microscope, and geochemistry by XRF.	14 samples were selected for potential mineralogy, petrography, and rock chemistry analyses.

Activity	"Hydrogeologic Workplan" (LANL 1998, 59599)	R-23 Sampling and Analysis Plan (LANL 2002, 73390)	R-23 Actual Work
Geophysics	In general, open-hole geophysics includes caliper, electromagnetic induction, natural gamma, magnetic susceptibility, borehole color videotape (axial and side scan), fluid temperature (saturated), fluid resistivity (saturated), single-point resistivity (saturated), and spontaneous potential (saturated). In general, cased-hole geophysics includes: gamma-gamma density, natural gamma, and thermal neutron.	The number and types of logs will vary as function of borehole condition and the presence or absence of drill or well casing. In general, open-hole geophysics includes: caliper, array induction, triple litho density, combinable magnetic resonance, natural gamma, natural gamma ray spectrometry, epithermal compensated neutron, mechanical sidewall coring tool, fullbore formation microimager, and borehole color videotape (axial and side scan). In general, cased-hole geophysics includes: triple litho density, natural gamma ray spectrometry, natural gamma, and epithermal compensated neutron.	LANL tools: 0–599 ft bgs (cased), 599–840 ft bgs (open hole): Natural Gamma; 0–599 ft bgs (cased), 599-840 ft bgs (open hole): video; 0–826.6 ft bgs. Well: video, natural gamma 0–886. Schlumberger geophysics: 0–599 ft bgs (cased), 599-828 ft bgs (open hole): array induction, combinable magnetic resonance, triple litho density, natural gamma, elemental capture, and thermal-epithermal neutron.
Water-Level Measurements	Procedures and methods not specified in hydrogeologic work plan.	Water levels will be determined for each saturated zone by water-level meter or by pressure transducer.	Water level for the regional water table determined by water-level meter.
Field Hydraulic-Property Tests	Tests to be conducted not specified in hydrogeologic work plan.	Straddle-packer/injection tests will be performed in all screens completed below the regional water table.	Hydrologic testing was not conducted.
Surface Casing	Approximately 20-in. outer diameter (OD), extends from land surface to 10-ft depth in underlying competent layer and grouted in place.	Install 18-in. or 20-in. OD steel casing to approximately 60 ft.	18-in. OD steel casing set at 37 ft bgs, cemented in place
Conductor Casing	Unless other technical methods are applied, a temporary steel casing, up to 14-in. OD, will be advanced to total depth (TD) of borehole.	Install 11.75-in. OD steel casing from 0 to ~700 to 800 ft bgs, or approximately 100 ft above anticipated regional water level, or set thin-wall casing over problem zone(s) and seal off casing using whatever is required regulatorily.	11.75-in. OD drill casing from 0 to 729 ft bgs 9.625-in. OD drill casing from 0 to 887 ft bgs
Minimum Well Casing Size	6 5/8-in. OD	5-in. OD	5-in. OD x 4.5-in. inner diameter (ID) stainless steel casing w/ external couplings

Activity	"Hydrogeologic Workplan" (LANL 1998, 59599)	R-23 Sampling and Analysis Plan (LANL 2002, 73390)	R-23 Actual Work
Well Screen	Machine-slotted (0.01-in.), stainless steel screens with flush-jointed threads; number and length of screens to be determined on a site-specific basis and proposed to NMED.	Well screen shall be constructed with multiple sections of 5.5-in. OD stainless steel pipe with wire wrap (0.010-in. slot opening).	Screened intervals constructed of 5.56-in. OD (4.5-in. ID) pipe based, stainless steel, wire- wrapped, 0.010-in. slotted screen
Filter Material	>90% silica sand, properly sized for the 0.010-in. slot size of the well screen; extends 2 ft above and below the well screen.	Filter pack shall extend at least 5 ft and no more than 10 ft above and below each well screen. No differentiation made between primary and secondary filter packs.	Primary filter pack consisted of 20/40 silica sand placed in a layer 9.8 ft below and 27 ft above well screen. Secondary filter pack consisted of 30/70 silica sand placed in a layer 6.5-ft-thick above primary filter pack.
Annular Material (exclusive of filter materials)	Uncontaminated drill cuttings below sump and bentonite above sump.	Bentonite and cement in borehole or well annulus.	Slough in borehole and annulus below and around sump from TD to 3.3 ft above bottom of sump Bentonite seal and slough above screen and cement plug Cement plug from 303 to 315 ft bgs Inter-layered cement-bentonite grout and bentonite chips from surface to 76 ft bgs
Sump	Stainless steel casing with an end cap	Not specified	5-in. diameter stainless steel casing, 13.1-ft long, with an end cap
Bottom Seal	Bentonite	Bentonite	None

Appendix B

Drill-Additive Product Specifications
(CD attached to inside back cover)

Appendix C

Lithology Log

Geologic Unit	Lithologic Description	Sample Interval (ft bgs)	Elevation Range (ft above msl)
Qal, Alluvium	Unconsolidated sediments, moderate yellowish-brown (10YR 5/4), clayey gravel (GC) with sand +10F (i.e., plus No. 10 size sieved sample fraction): mostly subangular intermediate volcanic clasts (up to 1.0 cm). +35F (i.e., plus No. 35 size sieved sample fraction): 60% quartz and sanidine grains; 40% volcanic lithic fragments.	0–5	6527.8–6522.8
	Unconsolidated sediments, moderate brown (5YR 4/4), sand (SP), medium-grained, most grains broken, 80% intermediate volcanic clasts, 20% quartz and sanidine grains. Note: None of the sample was retained by the No. 10 sieve; Qal/Qbo contact estimated at 10 ft bgs.	5–10	6522.8–6517.8
Qbo, Otowi Member, Bandelier Tuff	Rhyolitic tuff, mottled, moderate brown (5YR 4/4) to pale yellowish-gray (5YR 8/1). WR (i.e., unsieved whole rock) sample contains 20% pumice; 10% quartz and sanidine phenocrysts; 70% lithic fragments. +10F: 90% subrounded vitric pumice (up to 1.0 cm) with single 1.5 cm andesite lithic fragment.	10–15	6517.8–6512.8
	Rhyolite tuff, pale yellowish-brown (10YR 6/2). WR sample contains 50% pumice; 10% phenocrysts; 40% lithic fragments. +10F: 90%–95% subrounded, white frothy pumice (up to 1.0 cm); 5%–10% volcanic lithic fragments (up to 5 mm), mostly dacite with some andesite. +35F: 45%–50% pumice; 45%–50% lithic fragments; 3%–5% quartz and sanidine phenocrysts.	15–25	6512.8–6502.8
	No cuttings recovered in this interval. Note: Qbo/Qbog contact estimated at 30 ft bgs.	25–30	6502.8–6497.8
Qbog, Guaje Pumice Bed	Tephra deposit, very pale orange-tan (10YR 8/2), pumiceous. WR sample contains 100% pumice. +10F: 100% subrounded to rounded frothy pumice (up to 1.2 cm).	30–35	6497.8–6492.8
	Tephra deposit, pale yellowish-brown (10YR 6/2), pumiceous. WR sample contains 70%–80% pumice; 5%–10% phenocrysts; 20%–30% lithic fragments. +10F: 80%–90% white subrounded vitric pumice (up to 5 mm); 10% dacite and andesite lithic fragments (up to 1.5 cm), minor basalt. Note: Qbog/Tb4 contact estimated at 36 ft bgs based on first basalt returns.	35–40	6492.8–6487.8
Tb4, Cerros del Rio basalt	Basalt, medium-dark gray (N4) with some volcaniclastic sediments. WR/+10F: 70%–80% vesicular porphyritic basalt with aphanitic groundmass; 20%–30% volcanic lithic fragments of intermediate composition and quartz and sanidine phenocrysts. Note: Tb4 begins at approximately 36 ft bgs.	40–45	6487.8–6482.8
	Basalt, brownish-gray (5YR 4/1), +10F: vesicular porphyritic basalt with aphanitic groundmass, 5%–7% phenocrysts of olivine and plagioclase, thin iron oxide coating on fractured surfaces, minor amounts of white clay coating vesicle surfaces.	45–50	6482.8–6477.8
	Basalt, medium-dark gray (N4), porphyritic with aphanitic groundmass, vesicular. +10F: 5%–7% phenocrysts of plagioclase and unaltered pale green olivine; trace of white clay lining vesicles from 60–65 ft.	50–65	6477.8–6462.8

Geologic Unit	Lithologic Description	Sample Interval (ft bgs)	Elevation Range (ft above msl)
Tb4, Cerros del Rio basalt	Basalt, medium-dark gray (N4), sparsely porphyritic with aphanitic groundmass, variable vesicularity. +10F: 3%–5% phenocrysts of plagioclase and slightly oxidized brown olivine; partial iron oxide coating on fractures and lining vesicles; locally white calcite coats fractures and chips.	65–80	6462.8–6447.8
	Basalt, medium-dark gray (N4), sparsely porphyritic with aphanitic groundmass, vesicular. +10F: phenocrysts of plagioclase and dark colored olivine (up to 1 mm), olivine is oxidized or replaced; trace of light tan clay lining vesicles.	80–90	6447.8–6437.8
	Basalt, medium-dark gray (N4), sparsely porphyritic with phenocrysts of plagioclase and olivine (up to 2 mm); groundmass probably altered.	90–92	6437.8–6435.8
	No cuttings recovered in this interval.	92–97	6435.8–6430.8
	Basalt, brownish-gray (5YR-4/1) to medium-dark gray (N4), vesicular, porphyritic with phenocrysts of olivine (up to 2 mm) and mostly lath-shaped plagioclase (up to 2 mm), some olivine oxidized and iron-stained, some blocky plagioclase crystals; groundmass microcrystalline to aphanitic; some vesicles filled with alteration products or have iron-stained surfaces.	97–103	6430.8–6424.8
	Basalt, medium-dark gray (N4), vesicular to massive, porphyritic with phenocrysts of olivine (up to 2 mm) and lath-shaped plagioclase (up to 2 mm), some olivine oxidized and iron-stained; some vesicles have iron-stained surfaces or are infilled with material. +35F: 2%–3% quartz crystals (up to 3 mm).	103–113	6424.8–6414.8
	Basalt, medium gray (N5), mostly vesicular, porphyritic with phenocrysts of olivine (up to 2 mm) and lath-shaped plagioclase (up to 1 mm long); some coating and iron staining of vesicles; some rounded clayey sandstone clasts in +35F.	113–118	6414.8–6409.8
	Basalt, medium gray (N5), mostly massive, porphyritic with phenocrysts of olivine and lath-shaped plagioclase; minor amounts of quartz crystals and one quartz pebble.	118–123	6409.8–6404.8
	Basalt, medium-dark gray (N4) to grayish-red purple (5RP 4/2), abundant vesicles to scoriaceous, porphyritic with phenocrysts of olivine (up to 3 mm) and lath-shaped plagioclase (up to 2 mm long); iron staining common; vesicles filled with clay; quartz crystals comprise 5%–10% of the +35F.	123–128	6404.8–6399.8
	Basalt, medium-dark gray (N4), some vesicles, porphyritic with phenocrysts of olivine (up to 2 mm) and blocky to lath-shaped plagioclase (up to 2 mm long); groundmass microcrystalline to aphanitic; some vesicles filled with clay; minor iron staining; quartz crystals comprise 5% of +35F.	128–133	6399.8–6394.8
	Basalt, medium-dark gray (N4), sparse vesicles, mostly massive, porphyritic with phenocrysts of olivine (up to 2 mm) and lath-shaped to blocky plagioclase (up to 2 mm); very little iron staining or filling of vesicles.	133–148	6394.8–6379.8

Geologic Unit	Lithologic Description	Sample Interval (ft bgs)	Elevation Range (ft above msl)
Tb4 Cerros del Rio basalt	Basalt, medium gray (N5), very few vesicles, mostly massive, porphyritic with phenocrysts of olivine (up to 2 mm) and lath-shaped to blocky plagioclase (up to 2 mm); groundmass microcrystalline; iron staining absent.	148–158	6379.8–6369.8
	Basalt, medium gray (N5) to grayish-red purple (5RP 4/2), abundant vesicles to scoriaceous, porphyritic with generally unaltered phenocrysts of olivine (up to 2 mm) and lath-shaped plagioclase (up to 1 mm long). Secondary alteration of groundmass; vesicles lined with secondary alteration minerals, possibly including silica; iron staining common and some calcite evident.	158–168	6369.8–6359.8
	Basalt, grayish-red purple (5RP 4/2), vesicular, porphyritic with phenocrysts of olivine (up to 2 mm) and lath-shaped plagioclase (up to 1 mm long); secondary alteration of groundmass.	168–181	6359.8–6346.8
	Basalt, brownish-gray (5YR 4/1), vesicular, porphyritic with phenocrysts of olivine (up to 2 mm) and lath-shaped plagioclase (up to 1 mm long); secondary alteration of groundmass, blocky calcite crystals evident.	181–191	6346.8–6336.8
	Basalt, brownish-gray (5YR 4/1), sparse vesicles, porphyritic with phenocrysts of olivine (up to 2 mm) and blocky to lath-shaped plagioclase (up to 2 mm); secondary alteration of groundmass.	191–196	6336.8–6331.8
	Basalt, grayish-red purple (5RP 4/2), vesicular, porphyritic with phenocrysts of olivine (up to 3 mm) and both blocky and lath-shaped plagioclase (up to 2 mm); secondary alteration of groundmass; shape of vesicles not well defined.	196–206	6331.8–6321.8
	Basalt, medium gray (N5), massive, nonvesicular, porphyritic with phenocrysts of olivine (up to 2 mm) with abundant small (>0.5 mm) scattered olivine in groundmass, lath-shaped plagioclase (up to 2 mm long); secondary calcite crystals common (up to 1 mm); altered microcrystalline groundmass.	206–216	6321.8–6311.8
	Basalt, medium gray (N5), massive, porphyritic with phenocrysts of olivine (up to 2 mm) and abundant small (>0.5 mm) scattered olivine crystals and opaque pyroxene, both blocky and lath-shaped plagioclase (up to 2 mm). Slightly altered microcrystalline groundmass. Alteration less pronounced than basalts above.	216–236	6311.8–6291.8
	No cuttings recovered in this interval.	236–287	6291.8–6240.8
	Basalt, grayish black (N2) to grayish-red purple (5RP 4/2), abundant vesicles to scoriaceous, porphyritic with phenocrysts of olivine (up to 2 mm), no visible plagioclase; microcrystalline groundmass; small, secondary blocky calcite crystals, some silicification evident.	287–297	6240.8–6230.8
	Basalt, grayish black (N2) to grayish-red purple (5RP 4/2), vesicular to scoriaceous, porphyritic with phenocrysts of olivine (up to 2 mm); microcrystalline groundmass, silicification evident; some clay coating on chips.	297–302	6230.8–6225.8
	No cuttings recovered in this interval.	302–342	6225.8–6185.8

Geologic Unit	Lithologic Description	Sample Interval (ft bgs)	Elevation Range (ft above msl)
Tb4 Cerros del Rio basalt	Basalt, medium-dark gray (N4) scoriaceous, porphyritic with phenocrysts of olivine (up to 2 mm) and lath-shaped plagioclase (up to 2 mm); some silicification evident; few chips of clay and but clay lines some vesicles; some basalt chips are rounded, indicating probable sedimentary transport.	342–346	6185.8–6181.8
	Basalt, medium light gray (N6) scoriaceous, porphyritic with phenocrysts of olivine (up to 2 mm) and lath-shaped plagioclase (up to 2 mm); some calcite crystals; most chips and vesicles have clay coatings; rare chips of pinkish gray clay.	346–356	6181.8–6171.8
	Basalt, medium gray (N5) vesicular to massive, porphyritic with phenocrysts of olivine (up to 1 mm) and lath-shaped plagioclase (up to 2 mm); some secondary calcite crystals; most vesicles have clay coatings; altered microcrystalline groundmass.	356–361	6171.8–6166.8
	Basalt, light gray (N7), mostly massive with rarely vesicular, porphyritic with phenocrysts of olivine (up to 2 mm) and lath-shaped plagioclase (up to 2 mm long); abundant small crystals (<0.5 mm) of olivine, and sparse pyroxene.	361–371	6166.8–6156.8
	Basalt, light gray (N7), mostly massive with minor amount of vesicles, porphyritic with phenocrysts of olivine (up to 2 mm) and blocky to lath-shaped plagioclase (up to 1 mm); abundant small crystals (<0.5 mm) of olivine, sparse pyroxene.	371–386	6156.8–6141.8
	Basalt, medium light gray (N6), massive with rare vesicles. +10F: porphyritic with phenocrysts of olivine (up to 2 mm), blocky to lath-shaped plagioclase (up to 1 mm); abundant small crystals (<0.5 mm) of olivine, sparse pyroxene.	386–411	6141.8–6116.8
	Basaltic sediments, sand (SW) with silt, brownish-gray (5YR 4/1), silt to medium-grained sand, poorly sorted, subangular grains; sand grains are mostly lithic fragments of basalt with some quartz and cemented clay. +10F: basalt, similar to above unit. +35F: basalt and silicified basalt (similar to interval from 287–302 ft bgs); rare chips of pinkish-gray silica-cemented clay.	411–416	6116.8–6111.8
	Basalt, brownish-gray (5YR 4/1). WR sample contains some sand. +10F: basalt chips, mostly massive with rare vesicles, porphyritic with phenocrysts of olivine (up to 1 mm) and plagioclase laths (up to 2 mm long), abundant small crystals (<0.5 mm) of olivine, sparse pyroxene.	416–421	6111.8–6106.8
	Basalt, medium light gray (N6). WR sample contains some sand, +10F: massive basalt, porphyritic with phenocrysts of olivine (up to 1 mm), some very light in color, plagioclase laths (up to 2 mm long); rare pinkish-gray cemented clay chips; groundmass mostly microcrystalline. +35F: contains abundant grayish-brown basalt chips and some cemented clay chips.	421–431	6106.8–6096.8
	Basalt, medium light gray (N6). +10F: massive with some brownish-gray basalt, porphyritic with phenocrysts of olivine (up to 2 mm), with majority very light in color, visible plagioclase crystals are rare; groundmass mostly bleached to white in color; some chips coated with calcite.	431–451	6096.8–6076.8

Geologic Unit	Lithologic Description	Sample Interval (ft bgs)	Elevation Range (ft above msl)
Tb4 Cerros del Rio basalt	Basalt, medium gray (N5). +10F: massive, porphyritic with phenocrysts of olivine (up to 2 mm), some bleached; rare blocky plagioclase crystals, most very small to microcrystalline, abundant small (<0.5 mm) olivine, and some pyroxene; altered microcrystalline groundmass.	451–471	6076.8–6056.8
	Basalt with cemented clay chips, medium gray (N5), poor cuttings returned. +10F: porphyritic basalt with phenocrysts of olivine (up to 2 mm), many bleached; rare, small plagioclase crystals; groundmass microcrystalline. +35F: contains several cemented clay chips.	471–476	6056.8–6051.8
	Basalt and silty sand (SM) (possible interbed), pale yellowish-brown (10YR 6/2). WR sample contains 80% medium gray basalt; 20% sand, very fine to fine-grained, poorly sorted, angular grains, mostly quartz grains with some lithic fragments. +10F: basalt chips with few cemented clay chips. +35F: 80% basalt; 10% brown siltstone; 10% pale-orange cemented clay chips.	476–486	6051.8–6041.8
	Basalt and sandy siltstone (possible interbed), medium light gray (N6). WR sample contains mostly basalt with 10% sandy silt. +10F: 97% medium-dark gray basalt, mostly massive with few vesicles, aphanitic to microcrystalline, rare olivine phenocrysts (up to 1 mm), some plagioclase; 3% grayish-orange sandy siltstone. +35F: mostly basalt; 5% sandy siltstone; 2% cemented clay chips.	486–491	6041.8–6036.8
	Basalt and silty sandstone (possible interbed), medium light gray (N6). WR sample contains 95% basalt; 5% silty sand. +10F: mostly massive porphyritic basalt, rare vesicles, olivine phenocrysts (up to 1 mm); minor plagioclase (up to 0.5 mm); groundmass mostly microcrystalline; 1% silty sandstone; one euhedral quartz crystal. +35F: 97% basalt; 3% very fine-grained, silty, sandstone chips.	491–496	6036.8–6031.8
	Basalt and silty sandstone (possible interbed), medium light gray (N6). +10F: mostly massive porphyritic basalt, rare vesicles, olivine phenocrysts (up to 1 mm), plagioclase laths (up to 1 mm); 5% silty sandstone and sandy siltstone; few cemented clay chips and basalt chips with clay coating.	496–506	6031.8–6021.8
	Basalt with siltstone, medium light gray (N6). +10F: mostly massive basalt, sparse olivine and plagioclase phenocrysts (up to 1 mm), groundmass microcrystalline; 3% orange-pink siltstone with very fine-grained sand; rare basalt chips with cemented clay coatings.	506–511	6021.8–6016.8
	Basalt, medium gray (N5). +10F: mostly massive porphyritic basalt with rare vesicles, olivine phenocrysts are nearly clear (bleached), rare plagioclase phenocrysts, groundmass microcrystalline; 2%–3% pink tuffaceous siltstone; some basalt chips have white clay coatings.	511–521	6016.8–6006.8
	Basalt, medium gray (N5), porphyritic with aphanitic groundmass, WR: some clay. +10F: 85%–90% porphyritic basalt, olivine phenocrysts, both unaltered pale green, and completely replaced by limonite, groundmass mostly unaltered but with 10%–15% altered groundmass evident; trace of pink siltstone.	521–526	6006.8–6001.8

Geologic Unit	Lithologic Description	Sample Interval (ft bgs)	Elevation Range (ft above msl)
Tb4 Cerros del Rio basalt	Basalt, light brownish-gray, porphyritic with aphanitic groundmass, WR sample contains abundant clay chips. +10F: 93%–95% unaltered to strongly altered basalt; 5%–7% white very fine-grained clayey sandstone and siltstone; trace of basalt-rich sandstone. Probable contact between basalt and sediments at 530 ft. bgs.	526–531	6001.8–5996.8
Tb4, Cerros del Rio basalt, Interflow Sediments	Basalt/clastic sediments, sandy clay (SC) and basalt, grayish-orange pink (5YR 7/2). WR sample contains 85% sandy clay with 15% basalt chips; highly plastic clay contains some very fine-grained sand and silt. +10 F: mostly basalt, massive, aphanitic, few olivine phenocrysts and some plagioclase; 10% clayey sandstone chips. +35F: mostly basalt with 35% clayey sandstone chips.	531–536	5996.8–5991.8
	Basalt/clastic sediments, sandy silt (SM) and basalt, grayish-orange pink (5YR 7/2). WR sample contains mostly sandy silt with 30% basalt chips; sandy silt contains 20% very fine to fine-grained sand and has some clay content. +10F: 60% silty sand and sandy siltstone; 40% basalt, aphanitic, few olivine and plagioclase phenocrysts. +35F: 50% basalt; 50% sandy siltstone and silty sandstone; few cemented clay chips.	536–541	5991.8–5986.8
	Basalt/clastic sediments, sandy clay (SC), grayish-orange pink (5YR 7/2). WR sample contains 70%–75% clay; 20%–25% sand; 5%–7% basalt chips. +10F: 50% pinkish fine-grained sand and siltstone, sand grains of glassy basalt, feldspar, and possibly olivine; 50% angular, clay-coated basalt chips. +35F: 50% sandy clay; 50% basalt.	541–546	5986.8–5981.8
	Basalt/clastic sediments, sandy clay (SC) and basalt, grayish-orange pink (5YR 7/2). WR sample contains 30%–40% clay; 25%–35% sand; 15%–20% basalt chips. +10F: 35%–40% pink tuffaceous siltstone and claystone; 15%–20% fine-grained sand, grains of mafic crystals and feldspar, partially iron-stained; 35%–40% basalt chips.	546–551	5981.8–5976.8
	Basalt/clastic sediments, clayey gravel (GC) with sand, pale yellow-brown (10YR 6/2), basalt-rich. WR sample contains 70%–90% gravel; 10%–15% sand; 15%–30% fines. +10F: 60%–65% angular basalt chips; 7%–10% basaltic sandstone, grains of basalt, feldspar, and olivine, iron-stained; 30%–35% pinkish siltstone and claystone chips.	551–561	5976.8–5966.8
	Basalt/clastic sediments, clayey gravel (GC) with sand, pale yellowish-brown (10YR 7/2), basalt-rich. WR sample contains 70% gravel; 20% sand; 10%–15% fines. +10F: 70%–75% unaltered to altered basalt chips; 20%–25% fine-grained basaltic sandstone and pinkish claystone and siltstone; trace of calcite. +35F: 95% altered basalt; 5% sandstone and siltstone.	561–566	5966.8–5961.8
	Basalt/clastic sediments, clayey gravel (GC), pale yellowish-brown (10YR 7/2), basalt-rich. WR sample contains 75%–80% gravel; 5%–10% sand; 20%–30% fines. +10F: 80%–90% massive to vesicular basalt, aphanitic (lacks olivine), strongly altered, with brown staining; 10%–20% volcaniclastic sandstone and pinkish claystone and siltstone. +35F: abundant flakes of clay-altered basalt.	566–576	5961.8–5951.8

Geologic Unit	Lithologic Description	Sample Interval (ft bgs)	Elevation Range (ft above msl)
Tb4, Cerros del Rio basalt, Interflow Sediments	Basalt/clastic sediments, clayey gravel (GC), pale yellowish-brown (10YR 7/2), basalt-rich. WR sample contains 75%–80% gravel; 5%–10% sand; 20%–30% fines. +10F: 8%5–90% altered basalt or basaltic andesite, aphanitic, abundant flakes of clay-altered basalt; 10%–15% volcaniclastic sandstone and siltstone.	576–586	5951.8–5941.8
	Basalt/clastic sediments, siltstone and basaltic sandstone (SW), grayish-orange pink (5YR 7/2) coarse chips (up to 2.5 cm). WR/+10F: 75% pinkish claystone, siltstone and fine-grained sandstone, grains of basalt, feldspar, and mafic crystals; 20%–25% coarse subangular, aphyric chips (up to 2.0 cm) of basalt and basaltic andesite.	586–591	5941.8–5936.8
	Basalt/clastic sediments, clay (CH) to clayey sand (SC), grayish-orange pink (5YR 7/2). WR sample contains 10%–20% gravel; 40%–50% sand; 30%–40% fines. +10F: 40%–50% altered basalt and basaltic andesite, clayey with flakes of clay common; 40%–50% pinkish claystone, siltstone and tuffaceous sandstone; trace of crystalline calcite.	591–601	5936.8–5926.8
	Basalt/clastic sediments, gravel (GW) with clay and sand, pale yellowish-brown (10YR 6/2). WR sample contains 55%-65% gravel; 20%–30% sand; 10%–15% fines. +10F: 50%–55% broken and subangular chips of basalt, partially sericitized; 40%–45% pinkish, very fine-grained tuffaceous sandstone and siltstone, minor amounts of orange claystone, sandstone locally contains basalt lithic fragments.	601–611	5926.8–5916.8
	Basalt/clastic sediments, gravel (GW) with clay and sand, pale yellowish-brown (10YR 6/2). WR sample contains 40–50% gravel; 25%–35% sand; 10–15% fines. +10F: 80%–85% broken and subangular basalt chips, partially altered; 15%–20% pinkish-tan tuffaceous siltstone and claystone; 5%–7% basalt–rich volcaniclastic sandstone.	611–621	5916.8–5906.8
	Basalt/clastic sediments, clayey sand (SC), pale brown (5YR 5/2). WR sample contains 5%–15% gravel; 60%–70% sand; 20%–25% fines. +10F: only small amount retained; 45%–60% broken basalt chips, aphyric and porphyritic with phenocrysts of olivine, groundmass aphanitic, partially altered; 40%–55% pinkish tan, very fine-grained tuffaceous sandstone and siltstone.	621–631	5906.8–5896.8
	No cuttings returned in this interval.	631–636	5896.8–5891.8
	Basalt/clastic sediments, clayey sand (SC) to sand (SW) with clay, pale yellowish-brown (10YR 6/2). WR sample contains 5%–10% gravel; 55%–65% sand; 15%–25% fines. +10F: only small amount retained; 5%–10% broken basalt chips; 90%–95% pinkish very fine-grained sandstone, siltstone, and claystone. +35F: 20%–25% basalt; 75%–80% siltstone.	636–646	5891.8–5881.8
	Basalt/clastic sediments, clayey sand (SC) to sand (SW) with clay, pale yellowish-brown (10YR 6/2). WR sample contains 5%–7% gravel; 65%–70% sand; 15%–25% fines. +10F: 25%–35% broken basalt chips, partially altered; 65%–75% pinkish tuffaceous siltstone and claystone. +35F: Similar percentages and composition.	646–661	5881.8–5866.8

Geologic Unit	Lithologic Description	Sample Interval (ft bgs)	Elevation Range (ft above msl)
Tb4, Cerros del Rio basalt, Interflow Sediments	Basalt/clastic sediments, sand (SW) with clay and gravel, grayish orange-pink (5YR 7/2). WR sample contains 10%–20% gravel; 65%–75% sand; 10%–15% fines. +10F: 35%–45% broken basalt chips, aphyric, partly scoriaceous, and sericitized or silicified; 55%–65% pinkish fine-grained tuffaceous sandstone and siltstone.	661–671	5866.8–5856.8
	Basalt/clastic sediments, gravel (GW) with clay and sand, grayish-orange pink (5YR 7/2). +10F: 55%–60% broken basalt chips, massive and scoriaceous, partially clay altered, replacement by opaline silica evident; 40%–45% pink to orange very fine-grained tuffaceous sandstone and siltstone.	671–681	5856.8–5846.8
	Basalt/clastic sediments, gravel (GW) with clay and sand, light brown-gray (5YR 6/1). +10F: 65%–70% broken basalt chips, both massive and scoriaceous, frequently sericitized and bleached and/or replaced by opaline silica; 30%–35% pinkish siltstone and claystone.	681–691	5846.8–5836.8
	Basalt/clastic sediments, gravel (GW) with clay and sand, light brown-gray (5YR 6/1), contact with underlying basalt at approximately 692 ft. bgs. WR sample contains 60%–70% gravel; 25%–30% sand; 10%–15% fines. +10F: 80%–85% broken basalt chips, scoriaceous, moderately to strongly altered, majority replaced with opaline silica; 15%–20% pinkish very fine-grained tuffaceous sandstone and siltstone.	691–696	5836.8–5831.8
Tb4, Cerros del Rio basalt	Basalt, light olive-gray (5Y 6/1), aphyric, scoriaceous, clayey matrix binding chips. +10F: 90% broken basalt chips, dominantly scoria, pervasive silicification; 10% very fine-grained tuffaceous sandstone and siltstone.	696–701	5831.8–5826.8
	Basalt, light olive-gray (5Y 6/1), sparsely porphyritic with aphanitic groundmass, partly scoriaceous. +10F: 92%–95% broken and altered scoriaceous basalt chips, partly replaced by silica, with clay-lined vesicles; 5%–7% pinkish very fine-grained sandstone and white siltstone.	701–706	5826.8–5821.8
	Basalt, light olive-gray (5Y 6/1), sparsely porphyritic with aphanitic groundmass, alteration evident. +10F: 97%–98% broken basalt chips, less altered than interval above, chips are pitted and lined with mostly silica and some clay; 2%–3% pinkish very fine-grained sandstone and siltstone.	706–716	5821.8–5811.8
	Basalt, medium-light gray (N6), scoriaceous, sparsely porphyritic with aphanitic groundmass, alteration evident. +10F: 97%–99% broken scoriaceous basalt chips, small vesicles (< 0.5 mm), moderate to massive alteration by silica, clay lining vesicles and vugs, groundmass replaced by silica, minor unaltered olivine and plagioclase phenocrysts (up to 1 mm); 1%–3% pinkish very fine-grained sandstone and white siltstone.	716–731	5811.8–5796.8
	Basalt, medium-light gray (N6), scoriaceous, sparsely porphyritic with aphanitic groundmass, alteration evident. +10F: 97%–99% broken scoriaceous basalt chips, distinctive alteration, pitted, original glassy groundmass spotted with silica and clay, vesicles and vugs lined with drusy quartz crystals and clay, pervasive silicification between 741–746 ft. bgs; 1%–3% pinkish siltstone.	731–746	5796.8–5781.8

Geologic Unit	Lithologic Description	Sample Interval (ft bgs)	Elevation Range (ft above msl)
Tb4, Cerros del Rio basalt	Basalt, medium-light gray (N6), sparsely porphyritic with aphanitic groundmass, alteration evident. +10F: 96%–98% broken basalt chips, 1%–2% phenocrysts of olivine, pyroxene, and plagioclase, pyroxene is dark brown; phenocrysts generally unaltered; groundmass is mostly bleached, clay altered, and/or silicified; 2%–4% pinkish fine-grained sandstone and siltstone.	746–761	5781.8–5766.8
	Basalt, medium-light gray (N6), massive to vesicular and scoriaeous, porphyritic with aphanitic groundmass, alteration evident. +10F: 98%–99% broken basalt chips, 2%–3% phenocrysts of olivine, pyroxene, and plagioclase, pyroxene is dark brown to black; groundmass commonly bleached and altered, white clay has replaced plagioclase; 2%–3% pinkish fine-grained sandstone and siltstone.	761–771	5766.8–5756.8
	Basalt, medium-light gray (N6), massive to vesicular, porphyritic with aphanitic groundmass. +10F: 99% porphyritic basalt, 1%–3% phenocrysts of pyroxene, olivine, and plagioclase (up to 1 mm), generally unaltered, cumulophyric clusters of olivine; groundmass partially to totally bleached and altered.	771–781	5756.8–5746.8
	Basalt, medium-light gray (N6), porphyritic with aphanitic groundmass, partially altered. +10F: 97%–99% pyroxene bearing basalt, 1%–2% phenocrysts of black pyroxene, plagioclase, and olivine (up to 1.0 mm), generally unaltered; groundmass spotted or bleached and altered; 1%–3% very fine-grained sandstone and siltstone.	781–791	5746.8–5736.8
Tb4, Cerros del Rio basalt (791–795 ft bgs) Basaltic Sediments Unassigned Section (795–821 ft bgs)	Basalt, medium-light gray (N6), massive, porphyritic with aphanitic groundmass, partially altered. +10F: 98% basalt, 1%-2% phenocrysts of black pyroxene, plagioclase, and olivine (up to 1.0 mm), some in cumulophyric clusters, generally unaltered, groundmass spotted with clots of clay-altered feldspars, some totally bleached and altered; 2% very fine-grained sandstone and siltstone. Note: basal contact between Cerros del Rio basalt and underlying sediments containing basalt detritus is estimated at 795 ft bgs.	791–801	5736.8–5726.8
Basaltic Sediments (unassigned)	Clastic sediments/basalt, medium-light gray (N6), massive, porphyritic with aphanitic groundmass, partially altered. +10F: 99% broken basalt chips, 1%–2% phenocrysts of black pyroxene, plagioclase, and olivine (up to 1.0 mm), some in cumulophyric clusters, generally unaltered; groundmass spotted with clots of clay-altered feldspars, some totally bleached and altered 1% sandstone and siltstone; trace of subrounded quartzite granules; trace of calcite.	801–811	5726.8–5716.8

Geologic Unit	Lithologic Description	Sample Interval (ft bgs)	Elevation Range (ft above msl)
Basaltic Sediments (unassigned)	Clastic sediments/basalt, medium-light gray (N6), massive, porphyritic with aphanitic groundmass, moderately altered. +10F: 96%–98% broken basalt chips, 1%–2% phenocrysts of black pyroxene, plagioclase, and olivine (up to 1.0 mm), some in cumulophyric clusters, generally unaltered; groundmass spotted with clots of clay-altered feldspars, some totally bleached and altered. 2%–4% very fine-grained sandstone and siltstone; trace of quartzite granules. +35F: 1%-3% quartzite and pink to orange potassium feldspar grains.	811–821	5716.8–5706.8
Tsf, Santa Fe Group Sediments	Basalt and clastic sediments, light brownish-gray (5YR 6/1). WR: clayey matrix; 1%–3% quartzite clasts. +10F: 96%–98% broken to subangular basalt chips, altered; 2%–4% very fine-grained sandstone and siltstone. +35F: 8%5–90% basalt; 5%–8% quartzite and potassium feldspar (microcline); 3%–5% pale tan very fine-grained sandstone and siltstone.	821–826	5706.8–5701.8
	Basalt and clastic sediments, light brownish-gray (5YR 6/1), gravel (GW) with clay and sand. WR sample has a clayey matrix; 60% basalt; 40% quartzite, quartz and feldspars. +10F: 95%–96% altered basalt chips; 1%–2% quartzite and potassium feldspar (microcline) grains; 1%–2% very fine-grained sandstone and siltstone. +35F: 40% basalt; 50%–60% quartzite, quartz and feldspar; 3% sandstone.	826–831	5701.8–5696.8
	Clastic sediments, gravel (GW) with sand, light brownish-gray (5YR 6/1). +10F: 95%–97% broken chips of altered basalt; 2%–4% quartzite, quartz, and pink to orange potassium feldspars; 1%–2% siltstone. +35F: 30%–35% basalt; 65%–70% quartz, milky white quartzite, and potassium feldspar; 1%–2% siltstone.	831–841	5696.8–5686.8
	Clastic sediments, gravel (GW) with sand, light brownish-gray (5YR 6/1). WR sample contains 80%–85% quartzite, quartz, and feldspar clasts; 15%–20% subangular basalt clasts. +10F: 75%–80% broken chips of altered basalt; 15%–20% siltstone; 2%–4% quartz and quartzite grains. +35F: 15%–25% altered basalt and other volcanic lithic fragments (dacite); 75%–80% subangular grains of quartzite, quartz, and orange to pink potassium feldspar; 1%–3% sandstone.	841–856	5686.8–5671.8
	Clastic sediments, gravel (GW) with clay and sand, light brownish-gray (5YR 6/1). WR sample contains 80%–90% non-volcanic clasts (mostly quartzite and granitoids); 10%–20% volcanic clasts (mostly basalt). +10F: 75%–80% broken chips of mostly altered basalt, some subrounded dacite; 10%–15% quartzite, potassium feldspar, and other granitoid clasts; 5%-10% very fine-grained sandstone and siltstone. +35F: 20%-30% basalt and other volcanic lithic fragments; 70%–80% quartzite and granitoid clasts; 1%–2% sandstone.	856–866	5671.8–5661.8

Geologic Unit	Lithologic Description	Sample Interval (ft bgs)	Elevation Range (ft above msl)
Tsf, Santa Fe Group Sediments	Clastic sediments, sand (SW) with clay and gravel, light brownish-gray (5YR 6/1). WR sample contains 85%–90% non-volcanic, mostly quartzite and granitoid clasts; 10%–15% mostly basalt clasts; clayey matrix. +10F: 65%–75% broken basalt chips; 25%–35% quartzite, orange to pink potassium feldspar, and other granitoid clasts; 2%–3% siltstone; trace of calcite. +35F: 15%–20% volcanic lithic fragments, mostly basalt with some dacite; 80%–85% quartzite, quartz, and orange to pink potassium feldspar; 1%–2% sandstone. Note: +10F over-emphasizes basalt fraction in this interval.	866–881	5661.8–5646.8
	Clastic sediments, sand (SW) with clay, light brownish-gray (5YR 6/1). WR sample contains 85%–95% nonvolcanic clasts (mostly quartzite and granitoid clasts); 5%–15% volcanic clasts (mostly basalt). +10F: 55%–65% broken chips of mostly basalt with some dacite; 35%–45% quartzite, potassium feldspar, and other granitoid clasts; 2%–4% very fine grained sandstone and siltstone. +35F: 15%–20% volcanic clasts, mostly basalt; 80%-85% quartzite and granitoid grains; 1%–2% sandstone.	881–896	5646.8–5631.8
	Clastic sediments, sand (SW) with clay, light brownish-gray (5YR 6/1). WR sample contains 93%–95% non-volcanic clasts (mostly quartzite and granitoid clasts); 5%–7% volcanic clasts (mostly basalt). +10F: 30%–35% broken chips of mostly basalt with some dacite; 65%–70% quartzite, orange to pink potassium feldspar, and chert clasts; 2%–3% sandstone. +35F: 10%–15% volcanic clasts, mostly basalt; 85%–90% quartzite and granitoid grains; 1%–2% sandstone.	896–911	5631.8–5616.8
	Clastic sediments, sand (SW) with clay, light brownish-gray (5YR 6/1). WR sample contains 90% nonvolcanic clasts, mostly quartzite and granitoid clasts; 10% volcanic clasts (mostly basalt); clay matrix. +10F: 20%–30% broken chips of mostly basalt with some gray dacite; 75%–80% quartzite, potassium feldspar, chert clasts; 2%–3% very fine-grained sandstone and siltstone. +35F: 15% volcanic clasts, mostly basalt; 85% quartzite and granitoid grains; 1%–2% sandstone; trace of garnet crystals.	911–926	5616.8–5601.8
	Clastic sediments, clay (CH) with sand, grayish-orange pink (5YR 7/1). WR sample contains 40%–50% clay. +10F: 15%–20% subangular basalt clasts; 40%–45% quartzite, potassium feldspar, chert, and granitoid clasts; 30%–40% siltstone.	926–935	5601.8–5592.8
	R-23 BOREHOLE COMPLETED AT 935 FT BGS TOTAL DEPTH (TD).		

Notes:

1. American Society for Testing Materials (ASTM) standards (D 2488-90: Standard Practice and Identification of Soils [Visual-Manual Procedure]) were used to describe the texture of drill chip samples for sedimentary rocks such as alluvium and the Puye Formation. ASTM method D 2488-90 incorporates the Unified Soil Classification System (USCS) as a standard for field examination and description of soils. The following standard USCS symbols were used in the R-23 lithologic log:

SW = Well-graded sand	SM = Silty gravel	SC = Clayey sand
GW = Well-graded gravel	GM = Silty gravel	CH = Clay, high plasticity
GP = Poorly graded gravel	GC = Clayey gravel	

2. Cuttings at R-23 were collected at nominal 5-ft intervals and divided into three sample splits: (1) unsieved, or whole rock (WR) sample; (2) +10F sieved fraction (No. 10 sieve equivalent to 2.0 mm); and (3) +35F sieved fraction (No. 35 sieve equivalent to 0.50 mm).
3. The term *percent,* as used in the above descriptions, refers to percent by volume for a given sample component.
4. Color designations such as hue, value, and chroma (e.g., 5YR 5/2) are from the Geological Society of America's Rock Color Chart.

Appendix D

LANL Borehole Video Logs
(CD attached to inside back cover)

Appendix E

Schlumberger Geophysical Report/Montage
(CD attached to inside back cover)

Appendix F

Waste Characterization Data

Los Alamos
NATIONAL LABORATORY

Risk Reduction & Environmental Stewardship Division
Water Quality & Hydrology Group (RRES-WQH)
PO Box 1663, MS K497
Los Alamos, New Mexico 87545
(505) 667-7969/Fax: (505) 665-9344

Date: November 7, 2002
Refer to: RRES-WQH: 02-415

Mr. John Young
Hazardous Materials Bureau
New Mexico Environment Department
P.O. Box 26110
Santa Fe, New Mexico 87502

Mr. Curt Frischkorn
Ground Water Quality Bureau
New Mexico Environment Department
P.O. Box 26110
Santa Fe, New Mexico 87502

SUBJECT: NOTICE OF INTENT TO DISCHARGE, HYDROGEOLOGIC WORKPLAN WELL R-23

Dear Mr. Young and Mr. Frischkorn:

On November 1, 2002, your agency concurred with Los Alamos National Laboratory's proposal to land apply approximately 65,000 gallons of ground water produced during the development of Hydrogeologic Workplan Well R-23 (personal communication, Mr. Bob Beers, Los Alamos National Laboratory, and Mr. John Young, New Mexico Environment Department). The Laboratory's proposal to discharge development water from Workplan Well R-23 was made in accordance with the requirements of the Hydrogeologic Workplan Notice of Intent (NOI) submitted to your agency on August 2, 2001, and subsequently revised on July 16, 2002. Under the Hydrogeologic Workplan NOI, when development water produced from a Hydrogeologic Workplan Well exceeds a New Mexico Water Quality Control Commission (NM WQCC) Regulation 3103 ground water standard or a RCRA regulatory limit the Laboratory will coordinate disposal with the NMED. Since the development water produced from Workplan Well R-23 exceeds the NM WQCC Regulation 3103 ground water standard for manganese (Mn), your agency's concurrence was requested.

The Laboratory has containerized approximately 65,000 gallons of ground water produced during the development of Workplan Well R-23. Workplan Well R-23 is located on Pajarito Road near the intersection with State Road 4. Development water from Workplan Well R-23 will be land applied to the drill site (depth to groundwater is 827 ft.) or to the dirt road leading to Mortandad Canyon from Technical Area (TA)-52 (depth to groundwater is 1260 ft.). The preferred land application site is the R-23 drillsite, but wetland, habitat, and access issues may preclude use of this site. As required by the Workplan NOI, no ponding, pooling, or run-off of the discharged water will be permitted. Information regarding the quality of the development water is provided below.

Water Quality Data
Attachment 1.0 contains analytical reports (metals, general chemistry, perchlorate, nitrate, tritium, and high explosives) from the sampling of containerized development water from Workplan Well R-23.

Mr. Young and Mr. Frischkorn - 2 - November 7, 2002
RRES-WQH:02-415

All samples were filtered prior to analysis. Sample results were compliant with all NM WQCC Regulation 3103 ground water standards with the exception of the following contaminant:

Contaminant	Screening Result (mg/L)	NM WQCC ground water standard (mg/L)
Mn	0.44	0.2

No perchlorate, tritium, or high explosives (HE) were detected in the Workplan Well R-23 development water at concentrations greater than the analytical laboratory's Method Detection Limits (MDLs).

Please call me at (505) 667-6969 or Roy Bohn of the Laboratory's Environmental Restoration Project (RRES-R) at (505) 665-5138 if additional information is required.

Sincerely,

Bob Beers
Water Quality & Hydrology Group

BB/tml

Enclosures: a/s

Cy: M. Leavitt, NMED/GWQB, Santa Fe, NM, w/enc.
J. Davis, NMED/SWQB, Santa Fe, NM, w/enc.
J. Bearzi, NMED/HWB, Santa Fe, NM, w/enc.
J. Vozella, DOE/OLASO, w/o enc., MS A316
G. Turner, DOE/OLASO, w/enc., MS A316
M. Johansen, DOE/OLASO, w/enc., MS A316
B. Ramsey, RRES-DO, w/o enc., MS J591
K. Hargis, RRES-DO, w/o enc., MS J591
D. Stavert, RRES-EP, w/enc., MS J591
C. Nylander, RRES-GP, w/o enc., MS M992
S. Rae, RRES-WQH, w/enc., MS K497
D. Rogers, RRES-WQH, w/o enc., MS K497
M. Saladen, RRES-WQH, w/o enc., MS K497
J. McCann, RRES-WQH, w/o enc., MS M992
R. Bohn, RRES-R, w/enc., MS M992
D. Volkman, FWO-UI, w/o enc., MS K718
RRES-WQH File, w/enc., MS K497
IM-5, w/enc., MS A150

ATTACHMENT 1.0

HYDROGEOLOGIC WORKPLAN
WELL R-23

CONTAINERIZED DEVELOPMENT WATER

ANALYTICAL REPORTS:

- GENERAL CHEMISTRY
- METALS
- PERCHLORATE
- NITRATE/NITRITE
- HE
- TRITIUM

SAMPLE DATE:

October 17, 2002

Certificate of Analysis

Company : Los Alamos National Lab
Address : PO Box 1663
TA-3, Bldg. 271, Drop Pt. 01U
Los Alamos, New Mexico 87545
Contact: Keith Greene
Project: Groundwater Project

Report Date: October 25, 2002

Page 1 of 1

Client Sample ID:	GW23-02-49608 1/3	Project:	LANL00401
Sample ID:	69084001	Client ID:	LANL004
Matrix:	Ground Water		
Collect Date:	17-OCT-02		
Receive Date:	19-OCT-02		
Collector:	Client		

Parameter	Qualifier	Result	DL	TPU	RL	Units	DF	AnalystDate	Time	Batch Mtd.
Rad Liquid Scint										
LSC, Tritium Dist, Liquid										
Tritium		ND	140	44.1	250	pCi/L		JS1 10/23/02	1125	209717 1

The following Analytical Methods were performed

Method	Description
1	EPA 906.0

Notes:
TPU is calculated at the 67% confidence level (1-sigma).
The Qualifiers in this report are defined as follows :

- < Actual result is less than amount reported
- > Actual result is greater than amount reported
- B Analyte found in the sample as well as the associated blank.
- BD Flag for results below the MDC or a flag for low tracer recovery.
- E Concentration exceeds instrument calibration range
- H Holding time exceeded
- J Indicates an estimated value. The result was greater than the detection limit, but less than the reporting limit.
- P The response between the confirmation column and the primary column is >40%D
- U Indicates the compound was analyzed for but not detected above the detection limit
- UI Uncertain identification for gamma spectroscopy.
- X Lab-specific qualifier - must be fully described in case narrative and data summary package
- Y QC Samples were not spiked with this compound.

The above sample is reported on an "as received" basis.

This data report has been prepared and reviewed in accordance with General Engineering Laboratories, Inc. standard operating procedures. Please direct any questions to your Project Manager, Stacy Griffin.

Reviewed by

R-23 Development Water
Screening Results

ER

ER WATER SAMPLES

SAMPLE ID	DESCRIPTION	DATE MM/DD/YY	ER Req#	Ag ppm	Al ppm	Std.D. +/-	Alk(Lab) ppm CaCO3	As ppm	Std.D. +/-	B ppm	Std.D. +/-
GW23-02-49608	R-23 development water	10/17/02	13288	<0.001	0.013	0.001	95.1	0.0010	0.0001	0.029	0.001

Page 1

R-23 Development Water
Screening Results

ER

SAMPLE ID	Ba ppm	Std.D. +/-	Be ppm	Br ppm	C TIC ppm	C TOC ppm	Ca ppm	Std.D. +/-	Cd ppm	Cl ppm	ClO3 ppm	ClO4 ppm	Co ppm
GW23-02-49608	0.047	0.001	<0.001	0.04	21.5	26.5	25.1	0.1	<0.001	3.72	<0.02	<0.004	0.0012

Page 2

R-23 Development Water
Screening Results

ER

SAMPLE ID	Std.D. +/-	CO3 ppm	Cr ppm	Std.D. +/-	Cs ppm	Cu ppm	Std.D. +/-	F ppm	Fe ppm	Std.D. +/-	Hardness CaCO3 ppm	HCO3 ppm	Hg ppm	Std.D. +/-
GW23-02-49608	0.0001	0	0.0022	0.0001	<0.001	0.0014	0.0001	0.29	0.21	0.01	84.6	116	<0.0002	

Page 3

R-23 Development Water
Screening Results

ER

SAMPLE ID	K ppm	Std.D. +/-	Li ppm	Std.D. +/-	Mg ppm	Std.D. +/-	Mn ppm	Std.D. +/-	Mo ppm	Std.D. +/-	Na ppm	Std.D. +/-	Ni ppm	Std.D. +/-	NO2 ppm
GW23-02-49608	2.75	0.03	0.029	0.001	5.33	0.05	0.44	0.01	0.0031	0.0001	16.5	0.3	0.0026	0.0001	<0.02

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R-23 Development Water
Screening Results

ER

SAMPLE ID	NO3 ppm	N total ppm	Oxalate ppm	Pb ppm	pH Lab	PO4 ppm	Rb ppm	Std.D. +/-	Sb ppm	Se ppm	Si ppm	Std.D. +/-	SiO2 ppm calc
GW23-02-49608	2.07	0.47	<0.02	<0.001	7.34	<0.05	0.006	0.001	<0.001	<0.001	31.2	0.4	66.8

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R-23 Development Water
Screening Results

ER

SAMPLE ID	SO4 ppm	Sn ppm	Sr ppm	Std.D. +/-	Th ppm	Ti ppm	Tl ppm	U ppm	Std.D. +/-	V ppm	std.D. +/-	Zn ppm	Std.D. +/-	HMX ppm
GW23-02-49608	11.2	<0.001	0.11	0.01	<0.001	<0.001	<0.001	0.0011	0.0001	0.005	0.001	0.001	0.001	<0.01

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R-23 Development Water
Screening Results

ER

SAMPLE ID	RDX ppm	1,3,5-TNB ppm	1,3-DNB ppm	TNT ppm	NB ppm	2a-4,6-DNT ppm	2,4-DNT ppm	Acetate ppm	Formate ppm
GW23-02-49608	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	*	*

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HYDROGEOLOGIC WORKPLAN
WELL R-23

CONTAINERIZED DEVELOPMENT WATER

ANALYTICAL REPORTS

- GENERAL CHEMISTRY
- METALS
- PERCHLORATE
- NITRATE/NITRITE
- HE
- TRITIUM

SAMPLE DATE:

October 17, 2002