DOE/NV/11718--381

Nevada
Environmental
Restoration
Project

Completion Report for Well ER-EC-1

December 2000

Environmental Restoration
Division

U.S. Department of Energy
Nevada Operations Office

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COMPLETION REPORT FOR WELL ER-EC-1

Prepared for:
U.S. Department of Energy
Nevada Operations Office
Las Vegas, Nevada

Prepared by:
Bechtel Nevada
Geological and Hydrological Services
Las Vegas, Nevada

December 2000

Work performed under Contract No. DE-AC08-96NV11718

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DOE/NV/11718--381

COMPLETION REPORT FOR WELL ER-EC-1

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Completion Report for Well ER-EC-1
DOE/NV/11718--381

ABSTRACT

Well ER-EC-1 was drilled for the U.S. Department of Energy, Nevada Operations Office in support of the Nevada Environmental Restoration Project at the Nevada Test Site, Nye County, Nevada. This well was drilled in the spring of 1999 as part of the U.S. Department of Energy's hydrogeologic investigation well program in the Western Pahute Mesa - Oasis Valley region just west of the Test Site. A 44.5-centimeter surface hole was drilled and cased off to the depth 675.1 meters below the surface. The hole diameter was then decreased to 31.1 centimeters for drilling to a total depth of 1,524.0 meters.

A preliminary composite, static, water level was measured at the depth of approximately 566.3 meters prior to installation of the completion string. One completion string with three isolated, slotted intervals was installed in the well.

Detailed lithologic descriptions with preliminary stratigraphic assignments are included in the report. These are based on composite drill cuttings collected every 3 meters and 31 sidewall samples taken at various depths below 680 meters, supplemented by geophysical log data. Detailed chemical and mineralogical studies of rock samples are in progress. The well penetrated Tertiary-age lava and tuff of the Timber Mountain Group, the Paintbrush Group, the Calico Hills Formation, the Crater Flat Group, and the Volcanics of Quartz Mountain. The preliminary geologic interpretation of data from Well ER-EC-1 indicates the presence of a structural trough or bench filled with a thick section of post-Rainier Mesa lava. These data also suggest that this site is located on a buried structural ridge that may separate the Silent Canyon and Timber Mountain caldera complexes.

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List of Acronyms and Abbreviations

BHA	bottom-hole assembly
BN	Bechtel Nevada
cm	centimeter(s)
C	(degrees) Celsius
DOE	U.S. Department of Energy
DOE/NV	U.S. Department of Energy, Nevada Operations Office
DRI	Desert Research Institute
EC	Electrical Conductivity
F	(degrees) Fahrenheit
FMP	Fluid Management Plan
ft	foot (feet)
gal	gallon(s)
gpm	gallons per minute
in.	inch(es)
IT	IT Corporation
lpm	liters per minute
LANL	Los Alamos National Laboratory
LiBr	lithium bromide
m	meter(s)
NAD	North American Datum
NTS	Nevada Test Site
TD	total depth
TFM	Thermal Flow Meter
TWG	Technical Working Group
UDI	United Drilling, Inc.
UGTA	Underground Test Area
USGS	United States Geological Survey
WPM-OV	Western Pahute Mesa - Oasis Valley

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1.0 Introduction

1.1 Project Description

Well ER-EC-1 was drilled for the U.S. Department of Energy, Nevada Operations Office (DOE/NV) in support of the Nevada Environmental Restoration Project at the Nevada Test Site (NTS), Nye County, Nevada. Well ER-EC-1 is the second of a series of wells to be drilled as part of the hydrogeologic investigation well program in the Western Pahute Mesa - Oasis Valley (WPM-OV) region of Nye County, Nevada. This program is part of the DOE/NV Environmental Restoration Division's Underground Test Area (UGTA) Project at the NTS. The goals of the UGTA project include evaluating the nature and extent of contamination in groundwater due to underground nuclear testing, and establishing a long-term groundwater monitoring network. As part of the UGTA project, scientists are developing computer models to predict groundwater flow and contaminant migration within and near the NTS. To build and test these models, it is necessary to collect geologic, geophysical, and hydrologic data from new and existing wells to define groundwater migration pathways, migration rates, and quality.

The goal of the WPM-OV program is to collect subsurface geologic and hydrologic data in a large, poorly characterized area down-gradient from Pahute Mesa where underground nuclear tests were conducted, and up-gradient from groundwater discharge and withdrawal sites in Oasis Valley northeast of Beatty, Nevada (Figure 1-1). Data from these wells will allow for more accurate modeling of groundwater flow and radionuclide migration in the region. Some of the wells may also function as long-term monitoring wells.

Well ER-EC-1 is located within the Nellis Air Force Range complex, approximately 4 kilometers (2.5 miles) west of the Area 20 underground nuclear test area and east of East Thirsty Canyon, on the southern edge of Pahute Mesa (Figure 1-1). The elevation of the dirt-fill drill pad at the wellhead is 1,836.6 meters (m) (6,025.6 feet [ft]) above mean sea level. The Nevada State Planar coordinates (North American Datum [NAD] 1983) at the wellhead are North (N) 6,272,524.4 and East (E) 512,074.6 m (N 20,579,107.0, E 1,680,031.6 ft). Additional site data are listed in Table 1-1.

IT Corporation (IT) was the principal environmental contractor for the project, and IT personnel collected geologic and hydrologic data during drilling. The drilling company was United Drilling, Incorporated (UDI), a subcontractor to Bechtel Nevada (BN). Site supervision,

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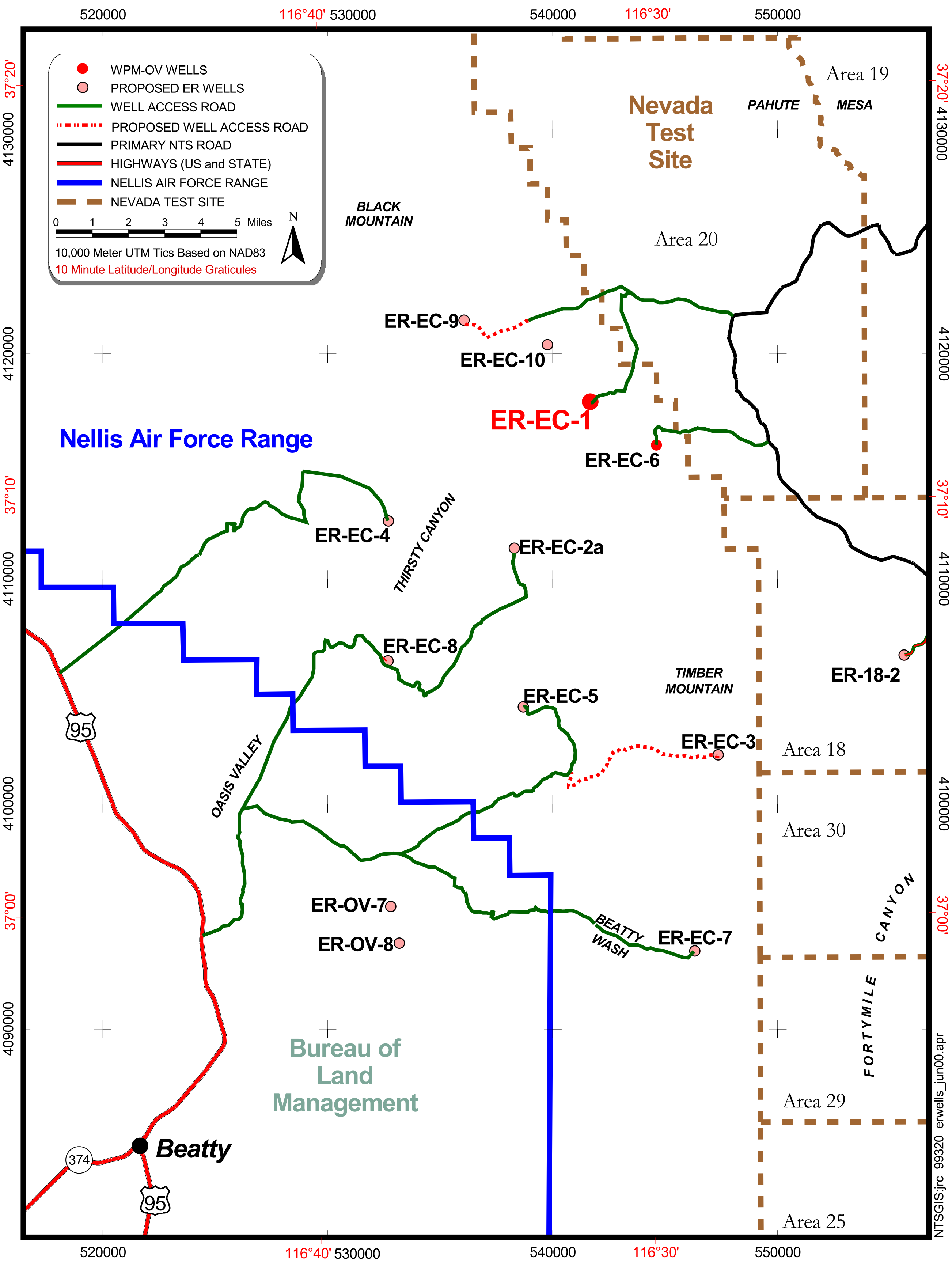

Figure 1-1
Reference Map Showing Location of Well ER-EC-1.
(Proposed wells not drilled at time Well ER-EC-1 was drilled.)

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Table 1-1
Well ER-EC-1 Site Data Summary

Well Designation	ER-EC-1
Site Coordinates [a]	Central Nevada State Planar (NAD 83): N 6,272,524.4 m (N 20,579,107.0 ft) E 512,074.6 m (E 1,680,031.6 ft) Central Nevada State Planar (NAD 27): N 894,105.2 ft E 539,876.1 ft Universal Transverse Mercator (Zone 11)(NAD 83): N 4,117,856.7 m E 541,649.5 m
Surface Elevation [b]	1,836.6 m (6,025.6 ft)
Drilled Depth	1,524.0 m (5,000 ft)
Fluid-Level Depth [c]	566.3 m (1,858 ft)
Fluid-Level Elevation	1,270.3 m (4,167.6 ft)

a Measurement by BN Survey. NAD 1983 and 1927.
b Measurement by BN Survey. Elevation at top of drill pad. North American Vertical Datum, 1929.
c Preliminary composite static water level.

engineering, construction, inspection, and geologic support were provided by BN. The roles and responsibilities of these and other contractors involved in the project are described in Contract Number DE-RP-08-95NV11808, and in BN Drilling Work Plan Numbers D-001-001.99 and D-004-001.99 (BN, 1998; BN, 1999b). The UGTA Technical Working Group (TWG), a committee of scientists and engineers comprising U.S. Department of Energy (DOE), Lawrence Livermore National Laboratory, Los Alamos National Laboratory (LANL), and contractor personnel, provided additional technical advice during drilling, design, and construction of the well. See *FY99 Western Pahute Mesa-Oasis Valley Hydrogeologic Investigation Wells Drilling and Completion Criteria* (IT, 1998) for descriptions of the general plan and goals of the WPM-OV project, as well as specific goals for each planned well.

General guidelines for managing fluids used and generated during drilling, completion, and testing of UGTA wells are provided in the UGTA Fluid Management Plan (FMP) (DOE, 1996a), an attachment to the UGTA Waste Management Plan (DOE, 1996b). Estimates of fluid and cuttings production for the WPM-OV holes are given in Appendix N of the drilling and completion criteria document for the WPM-OV project (IT, 1998), along with sampling requirements and contingency plans for management of any hazardous waste produced. All activities were conducted in accordance with the Nevada Environmental Restoration Project Health and Safety Plan (DOE, 1998) and the Site-Specific Health and Safety Plan for WPM-OV Investigation Wells (BN, 1999a).

This report presents construction data and summarizes scientific data gathered during drilling and installation of the completion string. Some of the information in this report is preliminary and unprocessed, but is being released so that drilling, geologic, and completion data can be rapidly disseminated. A well data report prepared by IT (IT, written communication, 1999) contains additional information on fluid management, waste management, and environmental compliance. Information on well development, aquifer testing, and groundwater analytical sampling will be disseminated after any such work is performed.

1.2 Objectives

The primary purpose of Well ER-EC-1 is to help characterize the hydrogeology of the area west of Pahute Mesa. Individual objectives, as discussed in Appendix A of the drilling criteria document (IT, 1998), include the following:

- Determine water levels to help define a north-south trending potentiometric trough that extends from Pahute Mesa to Oasis Valley.
- Define the boundaries of the Timber Mountain and Silent Canyon caldera complexes and determine their effect on groundwater flow.
- Evaluate the possibility that a deep groundwater flow regime exists in the area.

Some of these objectives will not be met until additional work is completed, including installing a pump and conducting hydraulic testing, and analyzing geology and hydrology data from this and other planned wells in the WPM-OV area.

1.3 Project Summary

This section summarizes Well ER-EC-1 construction operations; the details are provided in sections 2 through 8 of this report. The surface was prepared in December 1998, by blasting the hard surface layer to a depth of 14.6 m (48 ft). A 121.9-centimeter (cm) (48-inch [in.]) conductor hole was then auger-drilled to a depth of 23.5 m (77 ft). A string of 30-in. conductor casing was set at 23.3 m (76.4 ft) below ground level, and cementing was completed on January 6, 1999.

Drilling of the main hole with a 17½-in. rotary bit, using air-foam and conventional circulation, began on April 4, 1999, after completion of Well ER-EC-6. A suitable depth to set casing was reached at 675.1 m (2,215 ft). At this point, drilling was suspended for geophysical logging, and then 13⅜-in. surface casing was landed at 667.4 m (2,189.7 ft) on April 11, 1999, approximately 101 m (331 ft) below the static water level. Drilling continued with a 12¼-in. bit to a total depth (TD) of 1,524.0 m (5,000 ft), which was reached on April 19, 1999.

Water production was first noted at the depth of approximately 610.5 m (2,003 ft), and reached a maximum of about 2,270 liters per minute (lpm) (600 gallons per minute [gpm]) below the depth of approximately 1,435.6 m (4,710 ft). The preliminary composite static, water level prior to installation of the completion string was approximately 566.3 m (1,858 ft) below ground surface. No radionuclides above background levels were encountered during drilling of Well ER-EC-1.

Composite drill cuttings were collected every 3.0 m (10 ft) from 21.3 m (70 ft) to TD, and 31 sidewall core samples were taken at various depths below 680 m (2,230 ft). Open-hole geophysical logging of the well was conducted to help verify the geology and characterize the hydrology of the rocks; some logs also aided in the construction of the well by indicating borehole volume and condition, and cement location. The well penetrated Tertiary-age lava and tuff of the Timber Mountain Group, Paintbrush Group, Calico Hills Formation, Crater Flat Group, and Volcanics of Quartz Mountain.

A single completion string was installed in Well ER-EC-1 on April 26, 1999. Stainless steel, 5½-in. production casing was landed at 1,460.3 m (4,791.0 ft). The bull-nosed string has three slotted intervals, at 1,355.9 to 1,447.6 m (4,448.5 to 4,749.5 ft), 1,020.3 to 1,146.2 m (3,347.6 to 3,760.4 ft), and 700.4 to 860.0 m (2,297.9 to 2,821.4 ft). Internally epoxy-coated, 7-in. carbon-steel casing extends (via a crossover sub) from the top of the 5½-in. casing at 688.0 m (2,257.4 ft) to the ground surface. The completion string was gravel-packed across the slotted intervals and the remaining annular space was sealed with sand and cement to 486.8 m (1,597 ft) on April 27, 1999. No pump was installed at the time of completion.

1.4 Project Manager

Inquiries concerning Well ER-EC-1 should be directed to the UGTA Project Manager at:

Environmental Restoration Division
DOE/Nevada Operations Office
Post Office Box 98518
Las Vegas, Nevada 89193-8518

2.0 Drilling Summary

This section contains detailed descriptions of the drilling process and fluid management issues.

2.1 Introduction

The general drilling requirements for all WPM-OV wells were provided in *FY99 Western Pahute Mesa-Oasis Valley Hydrogeologic Investigation Wells Drilling and Completion Criteria* (IT, 1998), which also includes criteria for Well ER-EC-1 in Appendix A. Specific requirements for Well ER-EC-1 were outlined in drilling work plan numbers D-001-001.99 and D-004-001.99 (BN, 1998; BN, 1999b). The following information was compiled primarily from BN daily drilling reports. Figure 2-1 shows the layout of the drill site. Figure 2-2 is a chart of the drilling and completion history for Well ER-EC-1. A summary of construction data for the well is given in Table 2-1. Fluid management information (Section 2.4) was obtained primarily from IT's preliminary well data report (written communication, 1999).

2.2 Drilling History

Because the surface rock at the Well ER-EC-1 location was too hard for auger drilling, the upper part of the conductor hole was constructed by means of explosives placed in pre-drilled small-diameter holes. Field operations at Well ER-EC-1 began on December 2, 1998, with the excavation by backhoe of a shallow surface hole in which a temporary 66-in. casing was set to the depth of 0.8 m (2.5 ft) and cemented. This casing, fitted with a pattern cap, served as a guide for drilling of blast holes and a means of controlling dust. A "CP" 750 rig was moved in, and a BN crew began drilling the center-relief hole on December 9, 1998, using a 12¼-in. air hammer bit. Drilling continued through the cap rock to 14.6 m (48 ft) where a tight hole was encountered in softer material. Then seven 11.4-cm (4.5-in.) diameter shot holes (five along a radius of 63.5 cm [25 in.] and two at a radius of 38.1 cm [15 in.]) were drilled around the center-relief hole, and blasting took place on December 11, 1998. After the broken surface rock was removed, an auger rig was moved in on December 14, 1998, to complete the drilling of the conductor hole. The conductor hole was drilled with a 36-in. auger to 11.6 m (38 ft), and then another short section of temporary 66-in. casing was cemented into the enlarged upper part of the hole to stabilize the surface (the first piece of casing was blown out of the hole during blasting). Drilling continued to the depth of 23.5 m (77 ft), and opening of the hole to 121.9 cm (48 in.) was completed on December 31, 1998. A string of 30-in. conductor casing was set at a depth of 23.3 m (76.4 ft).

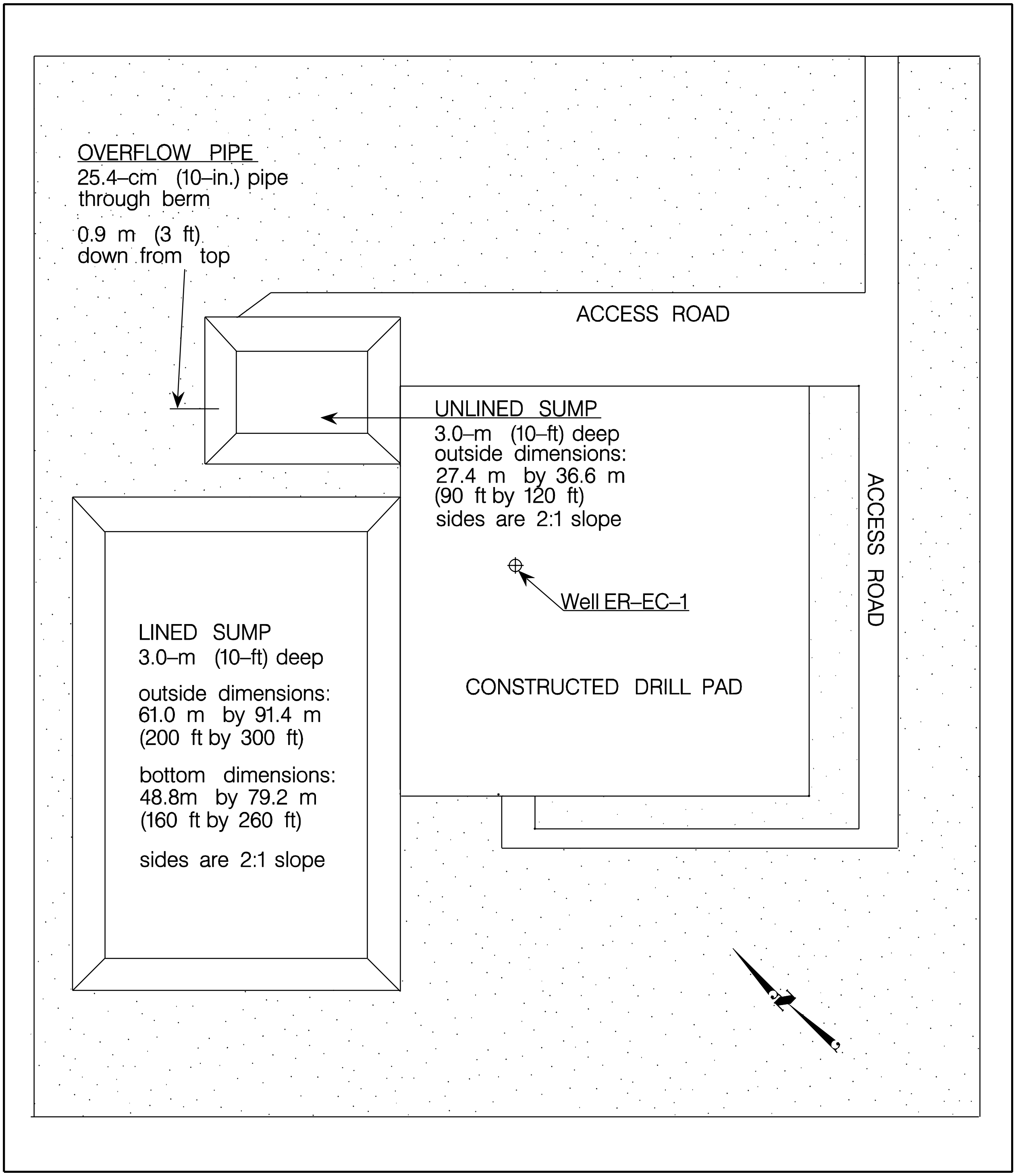

Figure 2-1
Drill Site Configuration for Well ER-EC-1

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WELL ER–EC–1 SUMMARY

Activity	Date
Set conductor casing at 0.8 m (2.5 ft):	12/1/1998
Begin drilling conductor hole:	12/15/1998
Conductor hole completed and cased to 23.2 m (76 ft):	1/4/1999
Begin drilling 17 1/2–in. surface hole:	4/5/1999
Surface casing set at 667.4 m (2,189.7 ft):	4/12/1999
Begin drilling 12 1/4–in. hole:	4/14/1999
Reach total drilled depth of 1,524.0 m (5,000 ft):	4/19/1999
Well completed:	4/27/1999

LEGEND

BHA Bottom hole assembly
TIH Trip into hole
TOH Trip out of hole

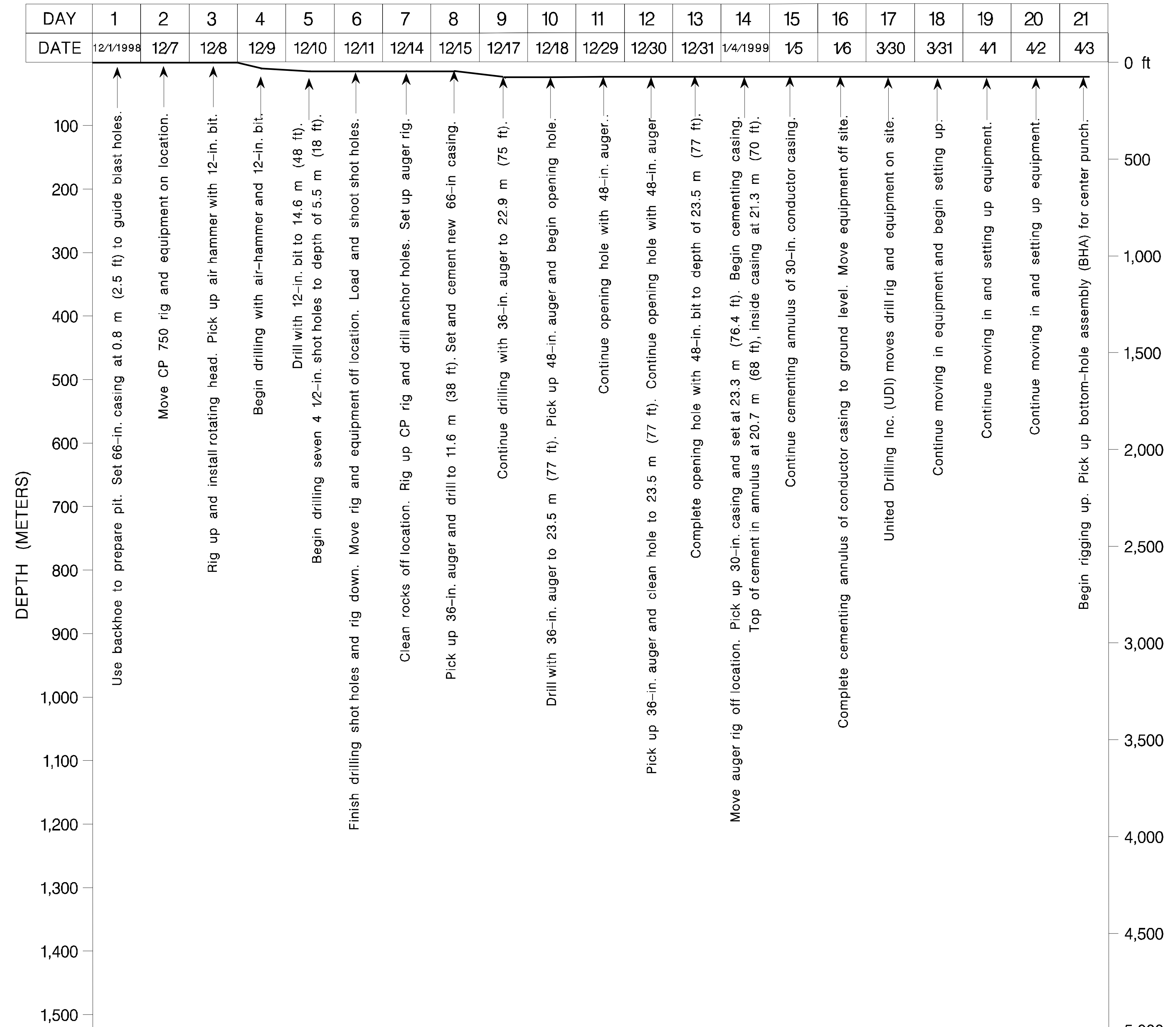
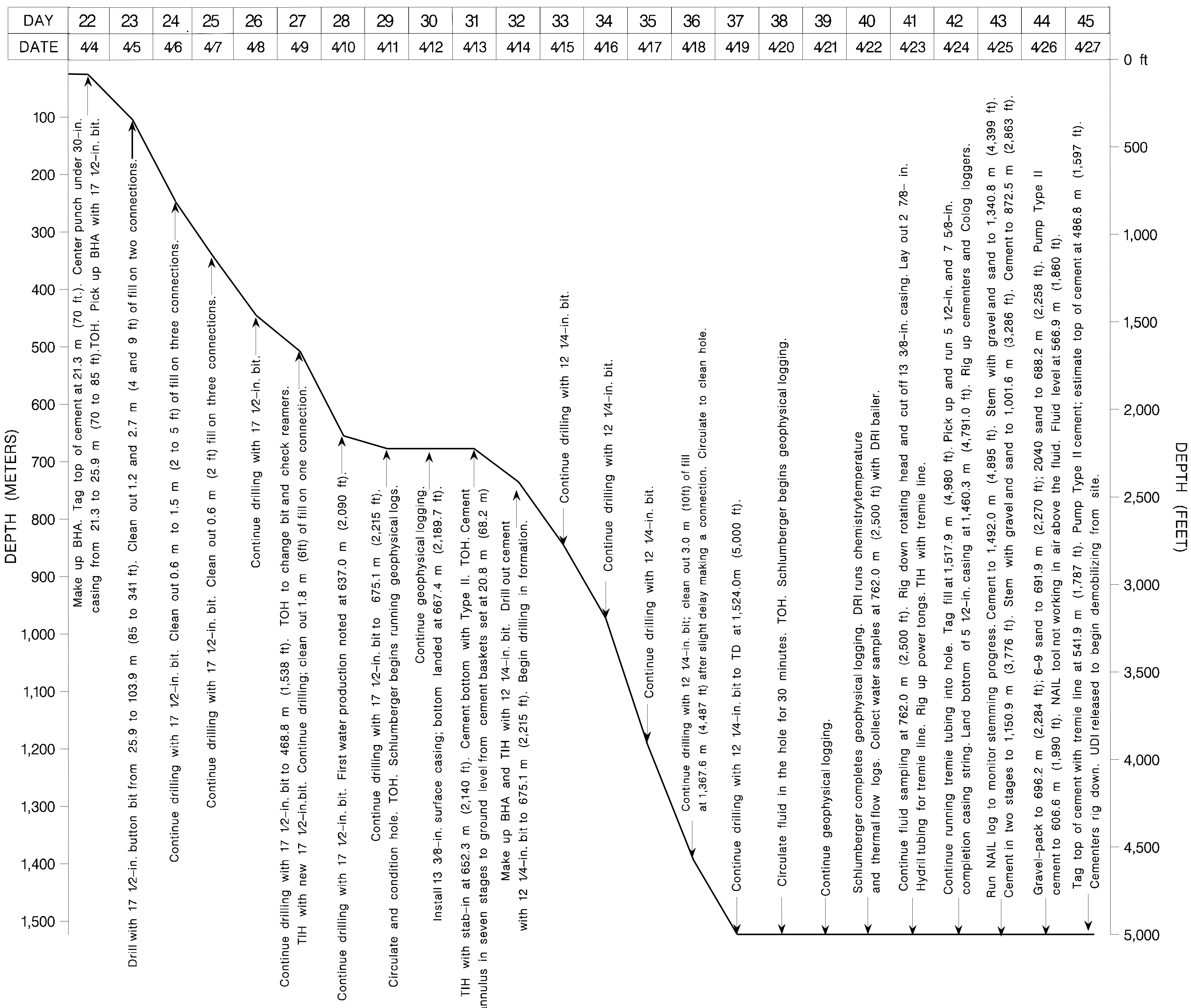


Figure 2-2
Well ER-EC-1
Drilling and Completion History
Sheet 1 of 2



LEGEND

BHA	Bottom hole assembly
NAIL	Nuclear Annulus Investigation Log
TD	Total depth
TIH	Trip into hole
TOH	Trip out of hole

Figure 2-2
Well ER-EC-1
Drilling and Completion History
Sheet 2 of 2

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Table 2-1
Abridged Drill Hole Statistics for Well ER-EC-1

LOCATION DATA:

Coordinates:	Central Nevada State Planar:	NAD 83:	N 6,272,524.4	E 512,074.6 m
		NAD 27:	N 894,105.2	E 539,876.1 ft
	Universal Transverse Mercator:	NAD 83:	N 4,117,856.7	E 541,649.5 m
Surface Elevation [a]		1,836.6 m (6,025.6 ft)		

DRILLING DATA:

Spud Date:	4/4/1999 (main hole with Wilson Mogul 42B rig)
Total Depth (TD):	1,524.0 m (5,000 ft)
Date TD Reached:	4/19/1999
Date Well Completed [b]:	4/27/1999
Hole Diameter:	121.9 cm (48 in.) from surface to 23.5 m (77 ft.); 44.4 cm (17.5 in.) from 23.5 to 675.1 m (77 to 2,215 ft.); 31.1cm (12.25 in.) from 675.1 m (2,215 ft) to TD of 1,524.0 m (5,000 ft)
Drilling Techniques:	Blasting of surface material, then dry-hole auger from surface to 23.5 m (77 ft.); center-punch with 17½-in. rotary bit mounted below a 26-in. hole-opener to 26.1 m (85.7 ft); rotary drilling with 17½-in. button bit and air-foam/polymer in direct circulation from 26.1 m (85.7 ft) to 675.1 m (2,215 ft); rotary drilling with 12¼-in. bit to TD of 1,524 m (5,000 ft).

CASING DATA: 30-in. conductor casing from surface to 23.3 m (76.4 ft.); 13⅜-in. surface casing from surface to 667.4 m (2,189.7 ft).

WELL COMPLETION DATA:

The completion string consists of 7⅝-in. carbon-steel casing with an internal epoxy coating, connected to 5½-in. stainless-steel casing via an internally coated carbon-steel crossover sub. The carbon-steel casing extends through the unsaturated zone approximately 122 m (400 ft) into the top of the saturated zone. The 14.0-cm (5½-in.) outside-diameter casing has a 12.83-cm (5.05-in.) inside diameter, is bull-nosed, and has three slotted intervals that each consist of alternating blank and slotted joints. Detailed data for the completion intervals are provided in Section 7 of this report.

Total Depth:	1,460.3 m (4,791.0 ft)		
Depth of Slotted Sections:	700.4 to 860.0 m (2,297.9 to 2821.4 ft)	1,020.3 to 1,054.7 (3,347.6 to 3,760.4 ft)	1,355.9 to 1,447.6 (4,448.5 to 4,749.4 ft)
Depth of Sand Pack:	688.2 to 696.2 m (2,258 to 2,284 ft)	1,003.1 to 1,011.3 m (3,286 to 3,318 ft)	1,340.8 to 1,351.2 m (4,399 to 4,433 ft)
Depth of Gravel Pack:	696.2 to 872.6 m (2,284 to 2,863 ft)	1,011.3 to1,150.9 m (3,318 to 3,776 ft)	1,351.2 to 1,492.0 m (4,433 to 4,895 ft)
Depth of Pump:	None installed at the time of completion.		
Water Depth:	Preliminary, composite, pre-development, fluid level at 566.3 m (1,858 ft),		

DRILLING CONTRACTOR: United Drilling, Inc.

GEOPHYSICAL LOGS BY: Barbour Well Surveying, Schlumberger Logging Services, Colog, Inc. Desert Research Institute, Gyrodata, Inc.

SURVEYING CONTRACTOR: Bechtel Nevada

a Elevation of ground level at wellhead. 1929 North American Vertical Datum.
b Date completion string was cemented. Pump will be installed at a later date.

The bottom of the casing was cemented inside to 21.3 m (70 ft), and the annulus was cemented from the bottom of the casing up to ground level on January 6, 1999.

Preparations for the drilling of the main hole, including delivering and setting up equipment on site, began March 30, 1999, after the construction of Well ER-EC-6 was completed. A Wilson Mogul 42B drilling rig was mobilized to the ER-EC-1 site on March 31, 1999, and the UDI crews were rigged up ready to drill the main hole on April 4, 1999. To assure proper alignment of the 44.5-cm (17.5-in.) hole under the 30-in. casing, the hole was center-punched with a bottom-hole assembly (BHA) made up of a 17½-in. button bit mounted below a 26-in. hole opener. The top of cement inside the conductor casing was tagged at 21.3 m (70 ft) and drilling continued through the cement until the 26-in. hole-opener reached the bottom of the conductor casing, and the 17½-in. bit was cutting rock at 26.1 m (85.7 ft.). A new BHA was then made up with a 17½-in. button bit, and drilling of the main hole was started April 5, 1999, with conventional circulation using compressed air, water, and soap ("air-foam") drilling fluid. Up to 2.7 m (9 ft), but typically about 0.6 m (2 ft), of fill (due to sloughing of the borehole wall) was encountered on some connections. Polymer was added to the fluid mix starting at the depth of approximately 94.5 m (310 ft), and the amount of polymer in the air-foam and the fluid injection rate were adjusted as necessary during drilling to maintain adequate circulation and penetration rate, and to prevent fill on connections. The bit was replaced due to wear at 468.8 m (1,538 ft). The first significant water production was noted at a depth of approximately 610.5 m (2,003 ft), based on dilution of lithium bromide (LiBr) tracer (IT, written communication, 1999).

As a precaution against sloughing of the upper section of unsaturated volcanic rocks, it was decided to install surface casing when a competent formation for supporting the casing was reached. The bottom of the surface hole was reached at 675.1 m (2,215 ft) on April 11, 1999. The drillers ran a foam sweep and circulated fluid to condition the hole for thirty minutes, then pulled four stands of pipe and waited thirty minutes before tagging bottom again. No fill was found, and the drillers tripped the drilling tools out of the hole. Drilling was suspended for 24 hours during geophysical logging prior to installation of casing.

A casing subcontractor landed 13d-in. casing with centralizers installed at 0.6 m (2 ft) above the guide shoe; 6.7 m (22 ft) above the guide shoe; above the float collar; and on the collar between the fourth and fifth joints. Two metal-petal cement baskets are located at 20.8 m (68.2 ft) below ground level. The casing was landed at 667.4 m (2,189.7 ft.) on April 12, 1999, and pre-flush clear water was pumped down the casing prior to cementing. A stab-in sub was seated in the cement shoe, and the seal was checked by pumping air down the drill pipe. Type II Portland cement was pumped inside the casing through the stab-in sub, followed by water to displace the cement into the annulus. The top of cement in the annulus was later determined by geophysical logs to be at the depth of 439.2 m (1,441 ft). After the drill pipe was tripped out of the hole, the annulus above the cement baskets was cemented to ground level in eight stages from the surface. Cementing of the surface casing was completed on April 14, 1999. The top of cement inside the casing was tagged at 654.4 m (2,147 ft) when the BHA was tripped back into the hole. Drilling of the 31.1-cm (12.25-in.) main hole resumed on April 14, 1999, and continued without major problems to the TD of 1,524.0 m (5,000 ft), reached on April 19, 1999.

Immediately after reaching TD, the drillers circulated fluid to condition the hole before the second phase of geophysical logging, which took place on April 20-23, 1999. Installation of the completion string began on April 23, 1999. Demobilization from the Well ER-EC-1 site began after gravel-packing and cementing were completed on April 27, 1999.

A directional survey was run inside the completion string in Well ER-EC-1 on October 12, 1999. These data indicate that at the lowest surveyed depth of 1,453.9 m (4,770 ft), the borehole had drifted 6.5 m (21.2 ft) to the northeast of the collar location. The hole is relatively straight except for a possible bend or “dogleg” near the depth of 823.0 m (2,700 ft). However, no difficulties were encountered at this depth during installation of the completion string.

A graphical depiction of drilling parameters including penetration rate, revolutions per minute, pump pressure, and weight on the bit is presented in Appendix A-1. See Appendix A-2 for a listing of casing materials. Drilling fluids and cements used in Well ER-EC-1 are listed in Appendix A-3.

2.3 Drilling Problems

No significant problems were encountered during the drilling of ER-EC-1. However, a late winter storm interfered with operations in early April. A zone of poor fluid returns was encountered at 542.5 m (1,780 ft) but thickening of the drilling fluid and increasing the rate of injection improved returns. Also, fill of generally less than 3.0 m (10 ft) was encountered periodically throughout drilling, but did not result in significant drilling delays. The Drilling Work Plan (BN, 1999b) contained provisions for setting intermediate casing in the event that sloughing hole conditions or high water production caused drilling difficulties, however, neither was a problem and intermediate casing was not required in Well ER-EC-1.

2.4 Fluid Management

Drilling effluent was monitored in accordance with the methods prescribed in the UGTA FMP (DOE, 1996a). The air-foam/polymer drilling fluid was circulated down the inside of the drill string and back up the hole through the annulus (conventional or direct circulation) and then discharged into a sump. Water used to prepare drilling fluids came from Water Well 20 located on Pahute Mesa on the NTS, and a LiBr tracer was added as a means of estimating groundwater production.

To manage the expected high water production, two sumps were constructed prior to drilling (Figure 2-1). The larger of the two, lined with a tri-layer composite of high-density polyethylene and low-density polyethylene 40 mils thick, was available for use if concentrations of radionuclides or other contaminants in the fluid exceeded FMP requirements. The unlined sump was constructed with an overflow pipe that would allow discharge to the ground surface when fluid in the sump reached the level of the pipe. On April 14, 1999, fluid discharge was diverted to the larger lined sump before the fluid level in the infiltration basin reached the overflow pipe. The lined sump was used for storage of the rest of the fluids produced at Well ER-EC-1.

Samples of drilling effluent were tested on site hourly for the presence of tritium, and every eight hours for lead. The on-site monitoring results indicate that tritium remained at background levels, and lead was undetectable during the entire drilling operation. On-site monitoring data were verified by an off-site laboratory. A sample from the unlined (infiltration) basin was analyzed during drilling to demonstrate compliance with the FMP (IT, 1999). After drilling was completed, a fluid sample was collected from the lined sump, and an additional sample was collected from the unlined sump. Water-quality data from these three samples are given in Appendix B.

The results of analyses of samples of drilling fluid collected at Well ER-EC-1 during drilling operations indicate that all fluid quality objectives were met, as shown on the fluid management reporting form dated April 21, 1999 (Appendix B). The form lists volumes of solids (drill cuttings) and fluids produced during well-construction operations, Stages I and II (vadose- and saturated-zone drilling; well development and aquifer testing will be conducted at a later date). The volume of solids produced was calculated using the diameter of the borehole (from caliper logs) and the depth drilled, and includes added volume attributed to a rock bulking factor. The volumes of fluids listed on the report are estimates of total fluid production, and do not account for any infiltration or evaporation of fluids from the sumps.

3.0 Geologic Data Collection

3.1 Introduction

This section describes the sources of geologic data obtained from Well ER-EC-1 and the methods of data collection. Improving the understanding of the subsurface structure, stratigraphy, and hydrogeology of the area southwest of Pahute Mesa was among the primary objectives of Well ER-EC-1, so the proper collection of geologic and hydrogeologic data from Well ER-EC-1 was considered fundamental to successful completion of the project.

Geologic data collected at Well ER-EC-1 consist of drill cuttings, sidewall core samples, and geophysical logs. Data collection, sampling, transfer, and documentation activities were performed in accordance with applicable contractor procedures.

3.2 Collection of Drill Cuttings

Composite drill cuttings were collected continuously from Well ER-EC-1 at 3.05-m (10-ft) intervals as drilling progressed from the depth of 21.3 m (70 ft) to the TD of the well at 1,524.0 m (5,000 ft). One sample was also taken from the 0 to 3-m (10-ft) interval. Triplicate samples were collected from 493 intervals, and in addition, the IT Field Representative collected two sets of reference samples from each of the cuttings intervals. One set was examined at the drill site for use in preparing field lithologic descriptions, and remains in the custody of IT. The other set was sent to R. G. Warren (LANL) where it remains. All other samples (i.e., three sets of 493 samples plus one surface sample) are stored under controlled conditions at the U. S. Geological Survey (USGS) Core Library. One of these sample sets was sealed with custody tape at the rig site and remains sealed as an archive sample; one set was left unsealed in the original sample containers; and the third set was washed and stored in accordance with standard USGS Core Library procedures.

3.3 Sidewall Core Samples

Schlumberger attempted to collect sidewall samples with a percussion-gun tool on April 11, 1999, before installation of the surface casing, but the tool malfunctioned and no cores were retrieved from the surface hole interval. On April 21, 1999, after TD was reached and before the completion string was installed, 31 sidewall core samples were successfully collected from Well ER-EC-1. Schlumberger still had problems with their percussion-gun tool and just three cores (out of 30 shots, 20 of which misfired) were obtained from the interval between 1,456.3 and 1,503.6 m (4,778 to 4,933 ft). Twenty-eight samples were then taken between

680.6 and 1,470.3 m (2,233 to 4,824 ft) with the rotary sidewall coring tool. Sample locations were selected by the IT Field Representative on the basis of field lithologic logs (with consideration of borehole conditions determined from caliper logs) to obtain adequate representation of the rocks encountered below 680.6 m (2,233 ft). These samples will help verify the stratigraphy and lithology penetrated. A list of samples, including sample recovery and the preliminary stratigraphic assignment of each sample, is given in Table 3-1.

3.4 Sample Analysis

Twenty-four samples of drill cuttings from various depths in Well ER-EC-1 were submitted to the LANL Earth and Environmental Sciences Division - Geology and Geochemistry laboratories for petrographic, mineralogic, and chemical analyses to aid in stratigraphic identification and for characterization of mineral alteration. At the time of this report, analysis of the samples was ongoing, as shown on Table 3-2.

3.5 Geophysical Data

Geophysical logs were run to further characterize the lithology, structure, and water content of the rocks encountered. In addition, logs were run to evaluate borehole conditions, to determine the fluid levels during the course of drilling, and to monitor completion progress. Geophysical logging was conducted during three stages of drilling and completion: prior to setting surface casing, prior to installing the completion well casing, and during well installation (annulus investigation log). Some logs were run in both the saturated and unsaturated zones of the borehole, while others (e.g., thermal flow log, chemistry log, acoustic borehole televiewer log, etc.) were run only in the saturated interval. A complete listing of the logs, dates run, depths, and service company is provided in Table 3-3. Preliminary geophysical data from the logs are reproduced in Appendix D.

The ultrasonic borehole imager lost acoustic signal after recording between 728.5 and 1,514.2 m (2,390 to 4,968 ft) due to low hydrostatic pressure in the hole. A repeat run was conducted which verified that tool performance was lost 198.1 m (650 ft) below the top of fluid. The formation microimager tool was then run in the interval 666.9 to 838.2 m (2,188 to 2,750 ft) to cover the interval missed by the ultrasonic borehole imager.

Table 3-1
Sidewall Core Samples from Well ER-EC-1

Core Depth meters (feet)	Tool Used [a]	Length Recovered cm (in.)	Stratigraphic Unit [b]
680.6 (2,233.0)	MSCT	3.81 (1.5)	Tpb
728.1 (2,388.9)	MSCT	3.81 (1.5)	Tpb
792.5 (2,600.0)	MSCT	5.08 (2.0)	Tpb
853.4 (2,800.0)	MSCT	3.81 (1.5)	Tpcm
947.9 (3,110.0)	MSCT	2.54 (1.0)	Thr
969.9 (3,182.0)	MSCT	5.08 (2.0)	Thr
970.8 (3,185.1)	MSCT	1.91 (0.75)	Thr
976.9 (3,205.1)	MSCT	3.81 (1.5)	Thr
1,028.4 (3,373.9)	MSCT	5.08 (2.0)	Thr
1,033.8 (3,391.9)	MSCT	5.08 (2.0)	Tcp
1,071.9 (3,516.9)	MSCT	5.08 (2.0)	Tcp
1,103.0 (3,618.9)	MSCT	5.08 (2.0)	Tcbs
1,104.0 (3,622.1)	MSCT	5.08 (2.0)	Tcbs
1,114.3 (3,655.9)	MSCT	5.08 (2.0)	Tcbs
1,126.9 (3,697.1)	MSCT	1.27 (0.5)	Tcbs
1,179.5 (3,869.9)	MSCT	5.08 (2.0)	Tcbs
1,210.1 (3,970.0)	MSCT	1.91 (0.75)	Tcbs
1,211.6 (3,975.0)	MSCT	3.81 (1.5)	Tcbs
1,222.3 (4,010.0)	MSCT	3.17 (1.25)	Tcbs
1,240.5 (4,070.0)	MSCT	5.08 (2.0)	Tcbs
1,240.7 (4,070.5)	MSCT	2.54 (1.0)	Tcbs
1,241.2 (4,072.1)	MSCT	1.27 (0.5)	Tcbs
1,280.2 (4,200.0)	MSCT	5.08 (2.0)	Tcbs
1,304.5 (4,279.9)	MSCT	5.08 (2.0)	Tqu
1,348.7 (4,425.0)	MSCT	1.27 (0.5)	Tqu
1,380.7 (4,529.9)	MSCT	5.08 (2.0)	Tqu
1,447.8 (4,750.0)	MSCT	5.08 (2.0)	Tqu
1,456.3 (4,778.0)	SWC	3.81 (1.5)	Tqu
1,470.3 (4,824.0)	MSCT	5.08 (2.0)	Tqbl
1,493.5 (4,900.0)	SWC	3.81 (1.5)	Tqbl
1,503.6 (4,933.0)	SWC	2.54 (1.0)	Tqbl

a SWC = Percussion sidewall core gun operated by Schlumberger; MSCT = rotary mechanical sidewall coring tool operated by Schlumberger.

b Preliminary stratigraphic assignments: Tpb = rhyolite of Benham; Tpcm = Pahute Mesa lobe of Tiva Canyon Tuff; Thr = mafic-rich Calico Hills formation; Tcp = Prow Pass Tuff; Tcbs = Stockade Wash lobe of Bullfrog Tuff; Tqu = Volcanics of Quartz Mountain; Tqbl = lower biotite-bearing rhyolite of Quartz Mountain. See Appendix C for more information on Well ER-EC-1 stratigraphy and lithology.

Table 3-2
Status of Rock Sample Analyses for Well ER-EC-1

Depth [a] meters (feet)	**Sample Type** [b]	**Analyses Performed** [c]				
		Petrographic	Mineralogic		Chemical	
		PS	MP	XRD	XRF	Fe^{+2}/Fe^{+3}
356.6 (1,170)	DA	QL	P	C	P	P
417.6 (1,370)	DA	QL	P	C	P	P
490.7 (1,610)	DA	QL	P	C	P	P
545.6 (1,790)	DA	QL	P	C	P	P
554.7 (1,820)	DA	QL	P	C	P	P
606.6 (1,990)	DA	QL	P	C	P	P
661.4 (2,170)	DA	QL	P	C	P	P
774.2 (2,540)	DA	QL	P	C	P	P
829.1 (2,720)	DA	QL	P	C	P	P
862.6 (2,830)	DA	QL	P	C	P	P
893.1 (2,930)	DA	QL	P	C	P	P
929.6 (3,050)	DA	QL	P	C	P	P
993.6 (3,260)	DA	QL	P	C	P	P
1,021.1 (3,350)	DA	QL	P	C	P	P
1,045.5 (3,430)	DA	QL	P	C	P	P
1,103.4 (3,620)	DA	QL	P	C	P	P
1,133.9 (3,720)	DA	QL	P	C	P	P
1,161.3 (3,810)	DA	QL	P	C	P	P
1,204.0 (3,950)	DA	P	P	C	P	P
1,219.2 (4,000)	DA	QL	P	C	P	P
1,316.7 (4,320)	DA	QL	P	C	P	P
1,417.3 (4,650)	DA	QL	P	C	P	P
1,478.3 (4,850)	DA	QL	P	C	P	P
1,508.8 (4,950)	DA	QL	P	C	P	P

a Depth represents base of 3.0-m (10-ft) sample interval.
b **DA** = drill cuttings that represent lithologic character of interval.
c Status of analyses at the time of this writing: **C** = Analysis complete; **QL** = qualitative analysis complete, detailed quantitative analysis pending; **P** = analysis pending. Analysis type: **PS** = polished thin section; **MP** = electron microprobe; **XRD** = x-ray diffraction; **XRF** X-ray fluorescence; **Fe^{+2}/Fe^{+3}** = wet chemical analysis for iron.

Table 3-3
Well ER-EC-1 Geophysical Log Summary
(Page 1 of 2)

Geophysical Log Type [a]	Log Purpose	Logging Service	Date Logged	Run Number	Bottom of Logged Interval [b] meters (feet)	Top of Logged Interval [b] meters (feet)
* Natural Gamma Ray Spectroscopy	Stratigraphic correlation, mineralogy, natural and man-made radiation	Schlumberger	4/11/1999 4/20/1999	SGR-1 SGR-2	659.0 (2,162) 1,514.2 (4,968)	23.3 (76.4) 655.9 (2,152)
* Gamma Ray / Four Arm Caliper	Stratigraphic correlation / borehole conditions, cement volume calculation	Schlumberger	4/11/1999 4/20/1999	SGR-1/CA4-1 GR-2/CA4-2	671.2 (2,202) 1,519.1 (4,984)	23.3 (76.4) 666.9 (2,188)
* Epithermal Neutron/Density / Gamma Ray / Caliper	Total water content / rock porosity / borehole conditions	Schlumberger	4/11/1999 4/21/1999	ENP-1/CDL-1/ GR-1/CAL-1 ENP-2/CDL-2/ GR-3/CAL-2	662.0 (2,172) 1,512.7 (4,963)	23.3 (76.4) 666.9 (2,188)
* Array Induction Log /Spontaneous Potential / Gamma Ray	Lithologic determination / stratigraphic correlation	Schlumberger	4/11/1999	IND-1/GR-1	669.0 (2,195)	23.3 (76.4)
* Dual Laterolog / Gamma Ray / *Spontaneous Potential	Saturated zone: water saturation / stratigraphic correlation	Schlumberger	4/21/1999	GR-4/DLL-1/SP	1,513.0 (4,964)	667.5 (2,190)
Ultrasonic Borehole Imager / Gamma Ray	Saturated zone: lithologic characterization, fracture and void analysis / stratigraphic correlation	Schlumberger	4/22/1999	UBI-1/GR-5	1,514.2 (4,968)	728.5 (2,390)
Formation Microimager / Gamma Ray	Saturated zone: lithologic characterization / fracture and void analysis / stratigraphic correlation	Schlumberger	4/22/1999	FMI-1/GR-6	838.2 (2,750)	666.9 (2,188)
Temperature / Gamma Ray	Saturated zone: groundwater temperature / stratigraphic correlation	Schlumberger	4/20/1999	TMP-1/GR-2	1,521.6 (4,992)	667.4 (2,189.7)
Gamma Ray / Digital Array Sonic A. Wave-form and variable density presentations * B. Sonic porosity and travel time (STC) computations	Saturated zone: A. Porosity, lithologic determination B. Fracture identification	Schlumberger	4/21/1999	GR-4/AC-1	1,505.7 (4,940) 1,503.9 (4,934)	667.5 (2,190) 667.5 (2,190)

Table 3-3
Well ER-EC-1 Geophysical Log Summary
(Page 2 of 2)

Geophysical Log Type [a]	Log Purpose	Logging Service	Date Logged	Run Number	Bottom of Logged Interval [b] meters (feet)	Top of Logged Interval [b] meters (feet)
Mechanical Sidewall Coring Tool	Geologic samples	Schlumberger	4/21/1999	MSCT-1	1,519.1 (4,984)	666.6 (2,187)
Percussion Sidewall Coring Gun	Geologic samples	Schlumberger	4/21/1999	SWC-2	1,503.6 (4,933)	1,456.3 (4,778)
* Thermal Flow Log	Rate and direction of groundwater flow in borehole	Desert Research Institute	4/22/1999	1	1,508.8 (4,950)	729.1 (2,392)
* Chemistry Log	Groundwater chemistry, formation transmissivity	Desert Research Institute	4/22/1999	1	1,517.6 (4,979)	566.6 (1,859)
Nuclear Annulus Investigation Log	Well construction monitoring	Colog	4/25-26/1999	1	1,460.0 (4,790)	422.1 (1,385)
Oriented Color Video	Lithologic characterization, fracture and void analysis, stratigraphic correlation, hole conditions	Barbour Well Surveying	4/12/1999	1	565.7 (1,856)	Ground Level
Directional Survey	Borehole deviation	Gyrodata Incorporated	10/12/1999	1	1,453.9 (4,770)	7.6 (25)

a Logs presented in geophysical log summary, Appendix D, are indicated by *.

b Depth below ground surface.

Overall, the quality of the geophysical data collected was acceptable. An apparent oscillation had been noted in some of the logs from the previous borehole, Well ER-EC-6, which was attributed to cyclical deformation of the borehole wall due to the BHA configuration (see DOE, 2000). This degradation in the well data was still notable on logs run in the upper part of Well ER-EC-1, but was apparently solved by a change in the BHA configuration for drilling of the lower part of the hole.

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4.0 Geology and Hydrogeology

This section summarizes the geology and hydrogeology of Well ER-EC-1. Bechtel Nevada geologists prepared the detailed lithologic descriptions presented in Appendix C, incorporating information from field lithologic descriptions by IT well-site geologists and geophysical log data. Stratigraphic assignments and identification of alteration mineralogy presented here and in the lithologic log are based primarily on preliminary mineralogic and chemical data and interpretations provided by R. G. Warren of LANL (written communications, 1999).

The data and interpretations presented in this section and in the detailed lithologic log reflect the current understanding of the geology of the study area, and incorporate results of analyses performed to date at LANL (Table 3-2). However, results from the pending mineralogic and chemical analyses and perhaps future studies could prompt revisions of these interpretations. The geologic interpretations of the wells constructed for the UGTA WPM-OV project will be updated if necessary after all drilling is complete and data have been analyzed in the context of the regional geologic setting.

4.1 Geology

Well ER-EC-1 is located on the southern edge of Pahute Mesa, which is capped in the vicinity of the well by ash-flow tuff of the Trail Ridge Tuff, a formation of the Thirsty Canyon Group (Figure 4-1). The well penetrated 123.1 m (404 ft) of rocks assigned to the Thirsty Canyon Group (Figure 4-2). Below the Thirsty Canyon Group, the well penetrated four units of the Timber Mountain Group: mafic-poor Ammonia Tanks Tuff, rhyolite of Tannenbaum Hill, mafic-rich Rainier Mesa Tuff, and rhyolite of Fluorspar Canyon. Only two formations of the Paintbrush Group, rhyolite of Benham and Pahute Mesa lobe of Tiva Canyon Tuff, were encountered below the Timber Mountain Group. Below the Paintbrush Group, the well encountered mafic-rich Calico Hills Formation overlying Prow Pass Tuff and the Stockade Wash lobe of Bullfrog Tuff, both part of the Crater Flat Group. The well reached TD in Volcanics of Quartz Mountain, consisting of the tuff of Schooner overlying lower biotite-bearing rhyolite of Quartz Mountain.

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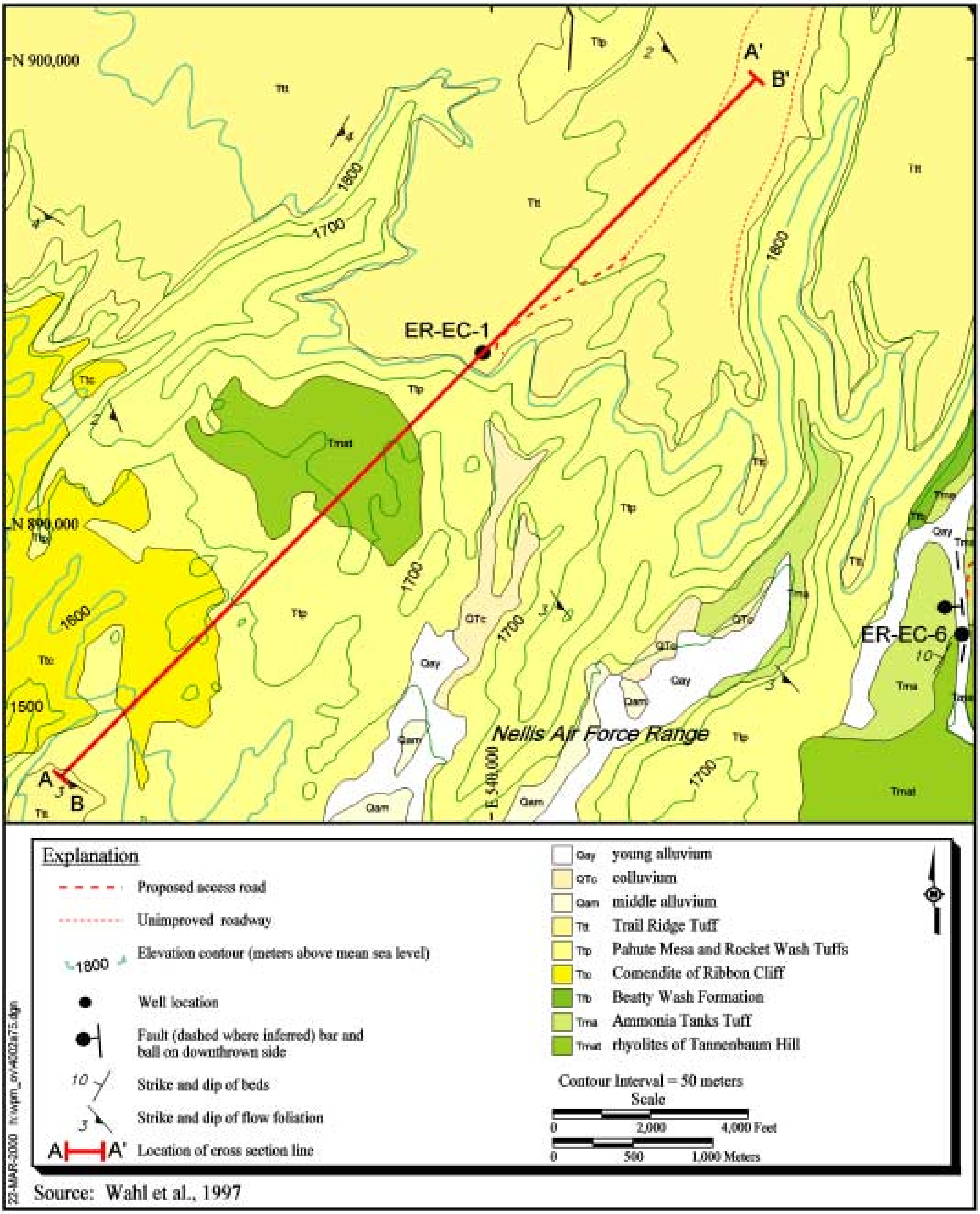

Figure 4-1
Surface Geologic Map of the Well ER-EC-1 Site

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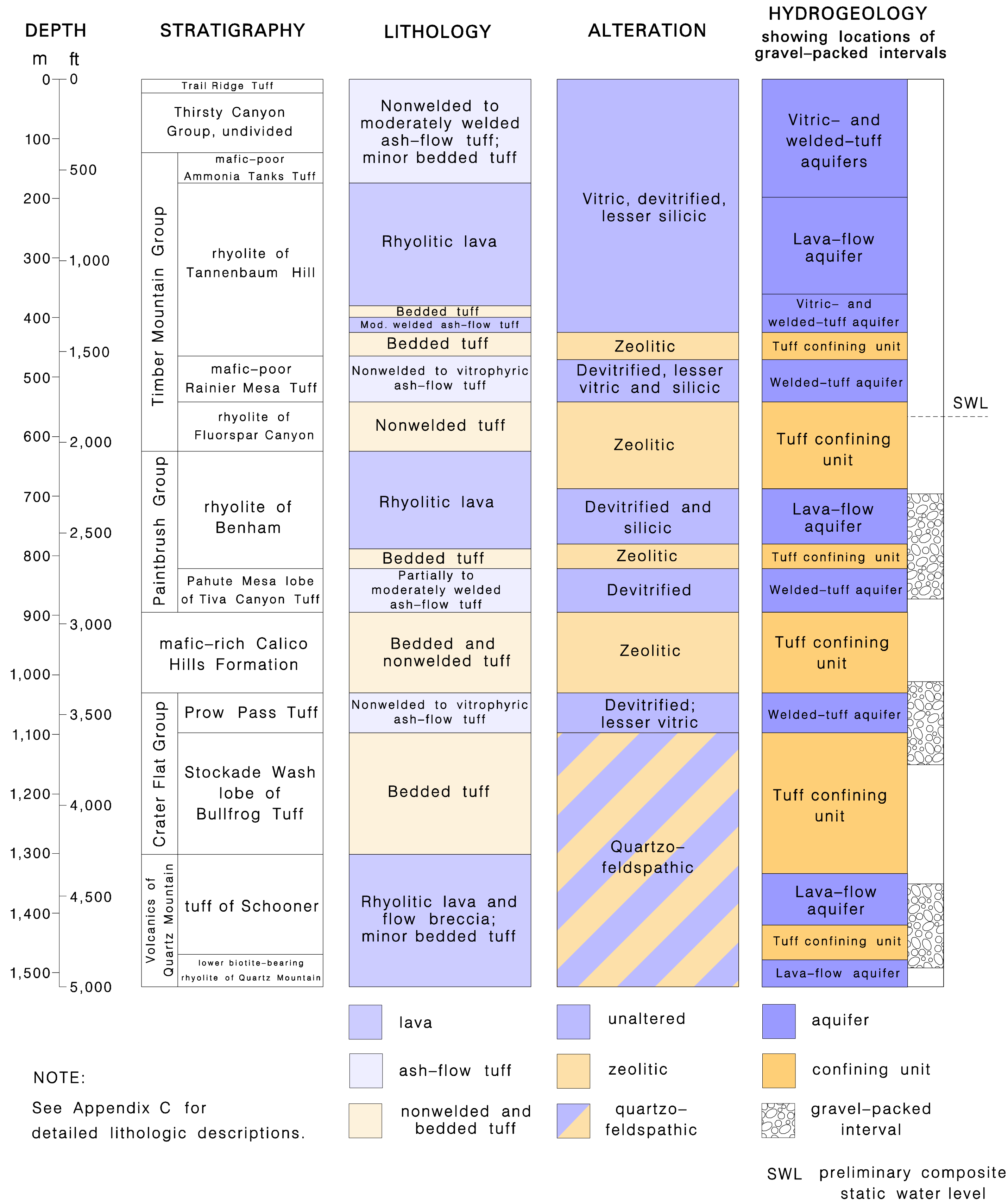

Figure 4-2
Geology and Hydrogeology of Well ER-EC-1

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The rocks encountered in Well ER-EC-1 include ash-flow tuff, rhyolitic lava, and nonwelded and bedded tuff (Figure 4-2). Three intervals of rhyolitic lava were encountered, including an upper interval 206.0 m (676 ft) thick, assigned to the rhyolite of Tannenbaum Hill; a middle interval 163.7 m (537 ft) thick, assigned to the rhyolite of Benham; and a lower interval 222.5 m (730 ft) of lava and flow breccia with minor bedded tuff comprising the tuff of Schooner and lower biotite-bearing lava of Quartz Mountain. The rhyolitic lavas include intervals of dense stoney lava, pumiceous lava, and vitrophyric lava. Lithologic features typical of rhyolitic lavas are present, including flow banding, spherulites, and perlitic textures.

At least seven individual ash-flow tuff units of the Thirsty Canyon, Timber Mountain, Paintbrush, and Crater Flat Groups were encountered at Well ER-EC-1. Individual ash-flows are generally less than 76.2 m (250 ft) thick and range in degree of welding from nonwelded to vitrophyric. Intervals of bedded and nonwelded tuff as thick as 204.2 m (670 ft) typically separate the intervals of rhyolitic lava and ash-flow tuff.

Rocks encountered above the depth of 424.9 m (1,394 ft) are vitric (unaltered), devitrified, and silicic. At lower depths, to 1,097.3 m (3,600 ft), the denser rocks such as lavas and welded tuffs are vitric and devitrified, while the less dense rocks such as pumiceous lavas and bedded and nonwelded tuffs are zeolitic (clinoptilolite). Below 1,097.3 m (3,600 ft), rocks show higher temperature, quartzo-feldspathic alteration consisting of secondary quartz and feldspar, as well as substantial zeolite (analcime). Unlike Well ER-EC-6, the rocks in Well ER-EC-1 show no evidence of pervasive hydrothermal alteration. A preliminary detailed log for Well ER-EC-1 is provided in Appendix C.

4.2 Predicted Versus Actual Geology

The predicted geology for Well ER-EC-1 was based partly on the locations of caldera margins as interpreted by Wahl et al. (1997) and illustrated in Figure 4-3. Preliminary data from Well ER-EC-1 indicate that the geology encountered is substantially different from that predicted prior to drilling (Figure 4-4), though this is not entirely unexpected, given the exploratory nature of this well. The most significant difference is that the Rainier Mesa Tuff was much thinner than expected, which clearly demonstrates that the well lies outside of the Rainier Mesa caldera, and that the structural margin of the caldera is south of the well location (Figure 4-5).

Like Well ER-EC-6, the geology encountered at Well ER-EC-1 indicates that, as predicted prior to drilling, this well is also located within the Northwestern Timber Mountain Bench of

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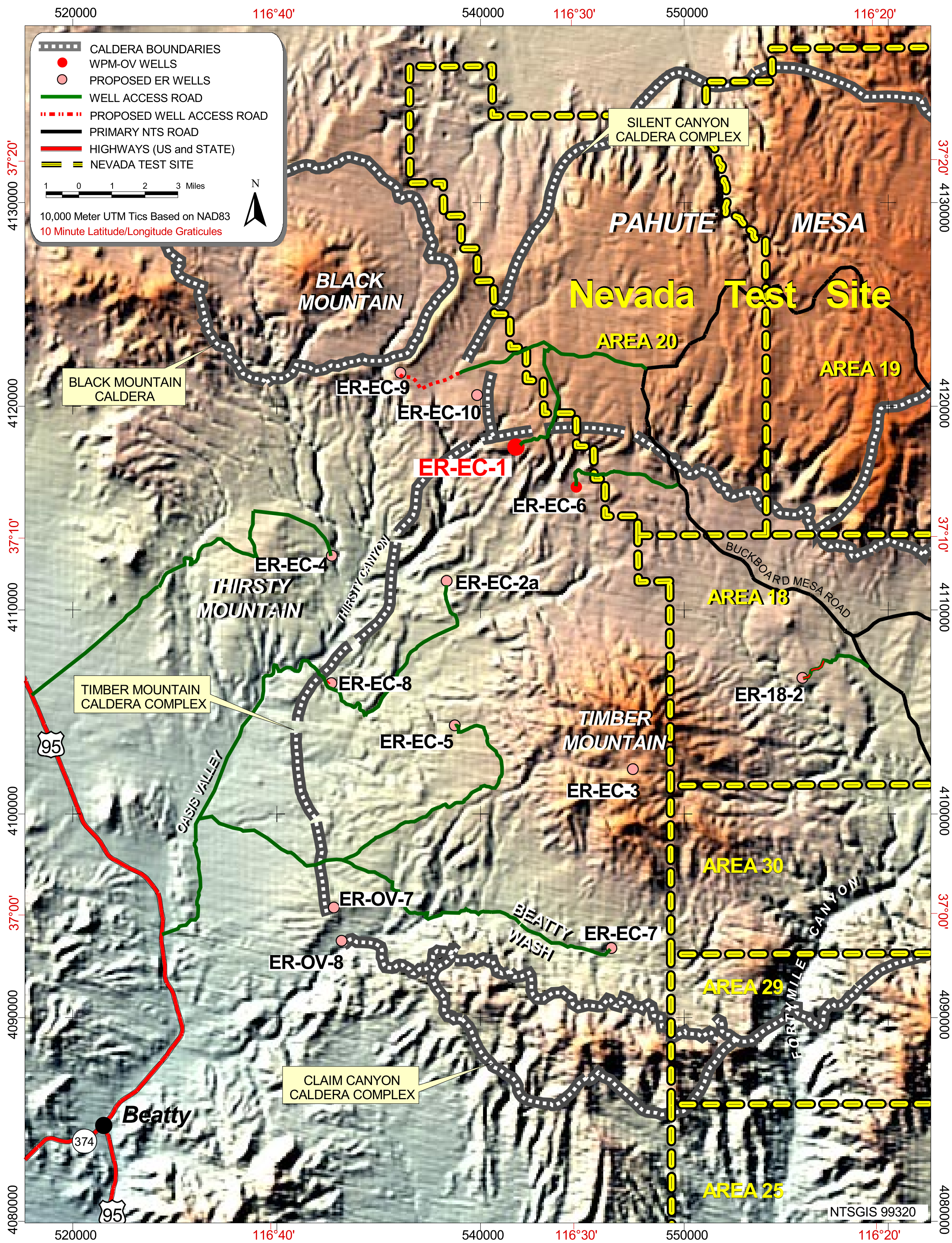

Figure 4-3
Map of Western Pahute Mesa - Oasis Valley Area Showing Locations
of Caldera Boundaries (after Wahl et. al., 1997)

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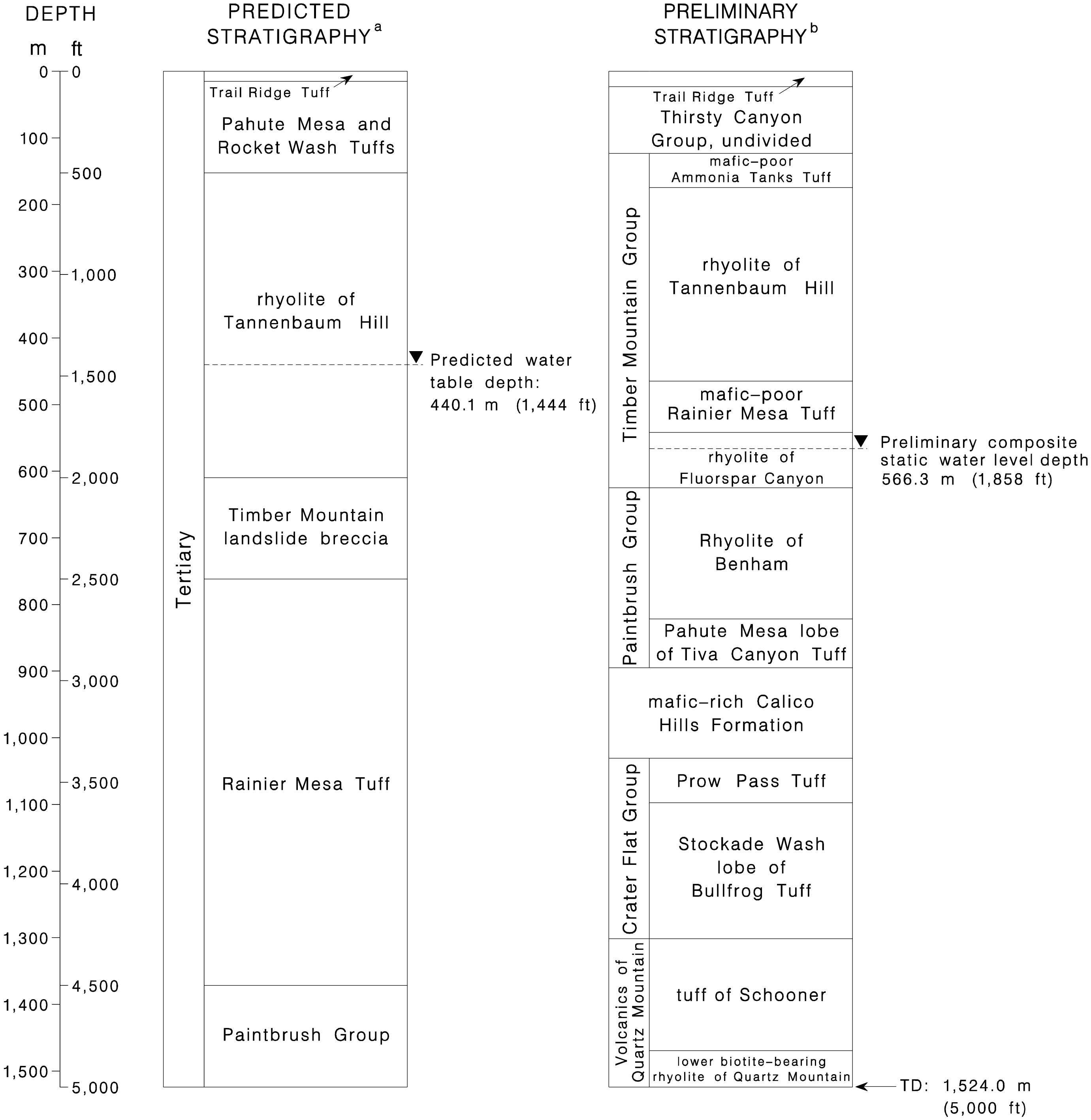

NOTES:

a IT, 1998
b See Appendix C for detailed lithologic descriptions.

Surface Elevation (pad): 1,836.6 m (6,025.6 ft)
Nevada Coordinates (NAD 27): N 894,105.2 ft; E 539,876.1 ft
Completed: 4/27/1999

Figure 4-4
Predicted and Preliminary Stratigraphy at Well ER-EC-1

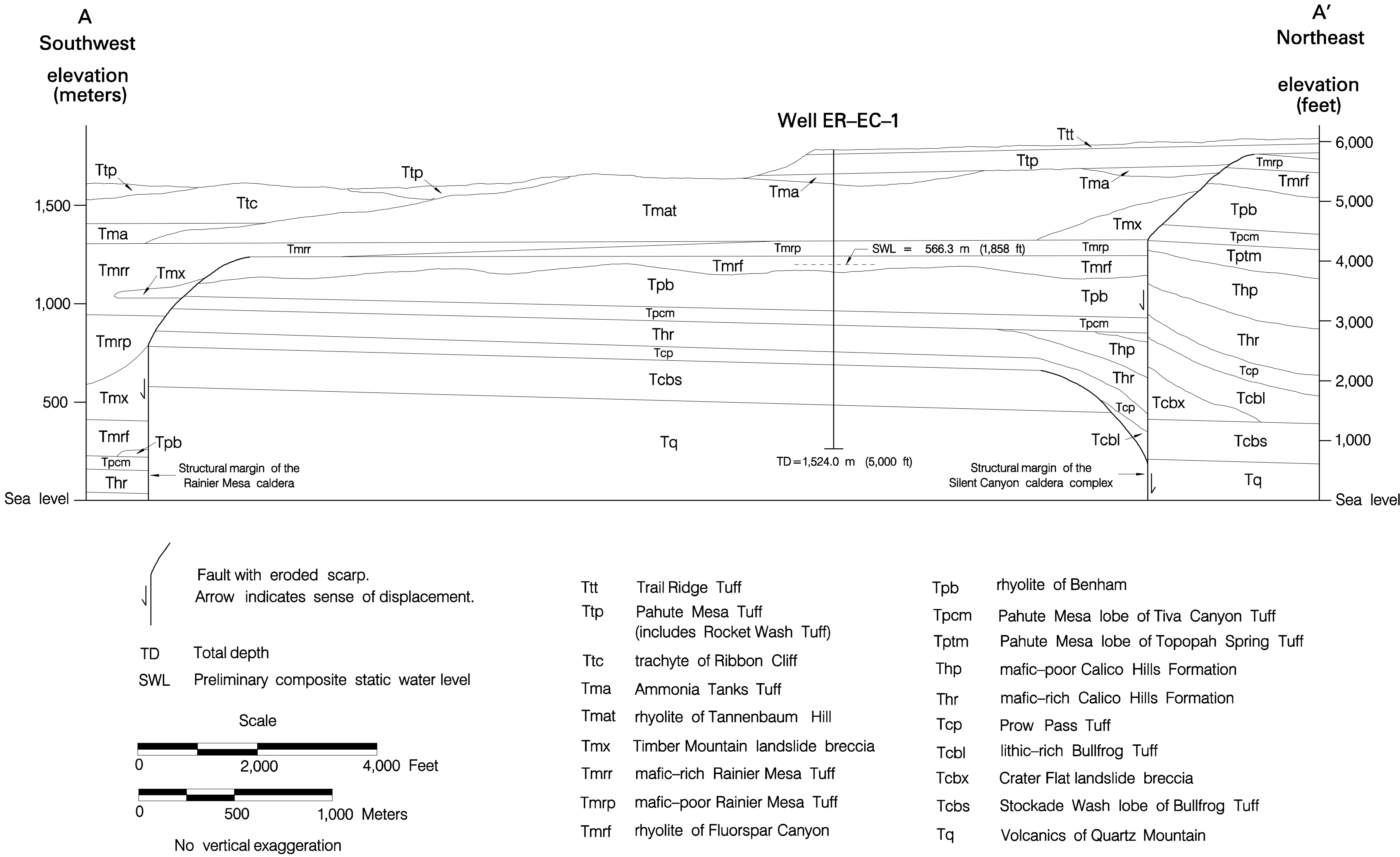

Figure 4-5
Preliminary Geologic Cross Section A-A' Through Well ER-EC-1

Warren (1994). Evidence for this structural "bench" is similar to that at Well ER-EC-6 (see DOE, 2000), and includes:

- considerably lower elevations (greater than 304.8 m [1,000 ft]) of the Rainier Mesa Tuff and the youngest Paintbrush Group units in Well ER-EC-1 compared to the same units in drill holes northeast of Well ER-EC-1;
- the presence of a thick section (290.5 m [953 ft]) of rhyolite of Tannenbaum Hill in Well ER-EC-1; and
- the absence of rhyolite of Tannenbaum Hill in holes northeast of the well.

Prior to drilling, the structural bench was thought to have been the site of deposition of a moderately thick section (approximately 609.6 m [2,000 ft]) of Rainier Mesa Tuff, which would have indicated that the bench developed during the eruption of the Rainier Mesa Tuff (IT, 1998; Warren, 1994). However, the presence of only 77.1 m (253 ft) of extra-caldera Rainier Mesa Tuff and thick rhyolite of Tannenbaum Hill in Well ER-EC-1 indicate that the structural bench formed after the eruption of the Rainier Mesa Tuff and prior to or during the eruption of rhyolite of Tannenbaum Hill, and functioned as a structural trough that controlled the deposition of the rhyolite of Tannenbaum Hill. Unlike the Well ER-EC-6 location where it appears that a pre-existing topographic high prevented deposition of Rainier Mesa Tuff, the pre-Rainier Mesa Tuff surface around Well ER-EC-1 must have been of a sufficiently low elevation to allow for the deposition of more than 61.0 m (200 ft) of Rainier Mesa Tuff in the area.

An alternate geologic scenario at Well ER-EC-1 was considered prior to drilling (IT, 1998). This scenario also predicted that Well ER-EC-1 would encounter moderately thick Rainier Mesa Tuff. However, in the alternate scenario the Rainier Mesa Tuff was depicted as overlying an extensive, low-angle erosional surface (made up of Crater Flat Group units) that formed as a result of large-scale mass wasting and erosion during formation of the Rainier Mesa caldera. The presence of the rhyolite of Fluorspar Canyon and only a thin section of Rainier Mesa Tuff overlying upper Paintbrush Group units in Well ER-EC-1 nullifies this alternate scenario.

Well ER-EC-1 was predicted to reach TD in units of the Paintbrush Group. However, because vertical displacement of the structural bench was less than previously thought, Well ER-EC-1 encountered the Paintbrush Group much higher than predicted, and the borehole penetrated completely through the Paintbrush Group. Below the Paintbrush Group, the borehole penetrated 406.6 m (1,334 ft) of rocks erupted from the Silent Canyon caldera complex, including mafic-rich Calico Hills Formation, Prow Pass Tuff, and Stockade Wash lobe of Bullfrog Tuff, before reaching TD in Volcanics of Quartz Mountain (which post-date the formation of the Silent Canyon caldera complex). The presence of only 406.6 m (1,334 ft) of rocks related to the Silent Canyon caldera complex in Well ER-EC-1, and the absence of Silent Canyon caldera-forming units such as the lithic-rich Bullfrog Tuff, clearly indicates that Well ER-EC-1 lies outside the structural margin of the Silent Canyon Caldera complex.

It is possible that the fault zone that forms the southern margin of the Silent Canyon caldera complex north of Well ER-EC-1 also serves as the northern bounding fault for the Northwestern Timber Mountain Bench on which Well ER-EC-1 is located.

In summary, the structural relationships in Well ER-EC-1 are similar to those at Well ER-EC-6 (DOE, 2000); they indicate that Well ER-EC-1 was drilled on a buried structural bench that formed after eruption of the Rainier Mesa Tuff, and was the site for the accumulation of thick post-Rainier Mesa Tuff lava (i.e., rhyolite of Tannenbaum Hill). The well is also located above a buried structural ridge that separates the Silent Canyon caldera complex to the northeast from the Timber Mountain caldera complex to the south. This is generally consistent with recent interpretations of gravity data in the region, which indicate a relatively thin section of volcanic rocks in the area of Well ER-EC-1 (Mankinen et al., 1999).

4.3 Hydrogeology

The rocks of Well ER-EC-1 have been subdivided into hydrogeologic units, as illustrated in Figure 4-2. A preliminary interpretation of the distribution of these units is shown in cross section on Figure 4-6. Because of the limited and preliminary nature of data in this area, and the difficulty in predicting the lateral continuity of hydraulic properties of volcanic rocks, the cross section is rather conjectural. However, it does illustrate the complexities associated with the distribution of hydrogeologic units in caldera settings such as at Well ER-EC-1.

Well ER-EC-1 penetrated seven separate intervals of rocks that likely behave as aquifers (Figure 4-2). However, the two uppermost aquifers occur above the water table, and thus are unsaturated. The remaining five saturated aquifers include three lava-flow aquifers and two welded-tuff aquifers, all separated by tuff confining units. The lava-flow aquifers consist of devitrified and quartzo-feldspathic rhyolitic lava and flow breccia. The welded-tuff aquifers consist of partially welded to vitrophyric, devitrified ash-flow tuff. The tuff confining units consist of zeolitic and quartzo-feldspathic bedded and nonwelded tuff and pumiceous lava.

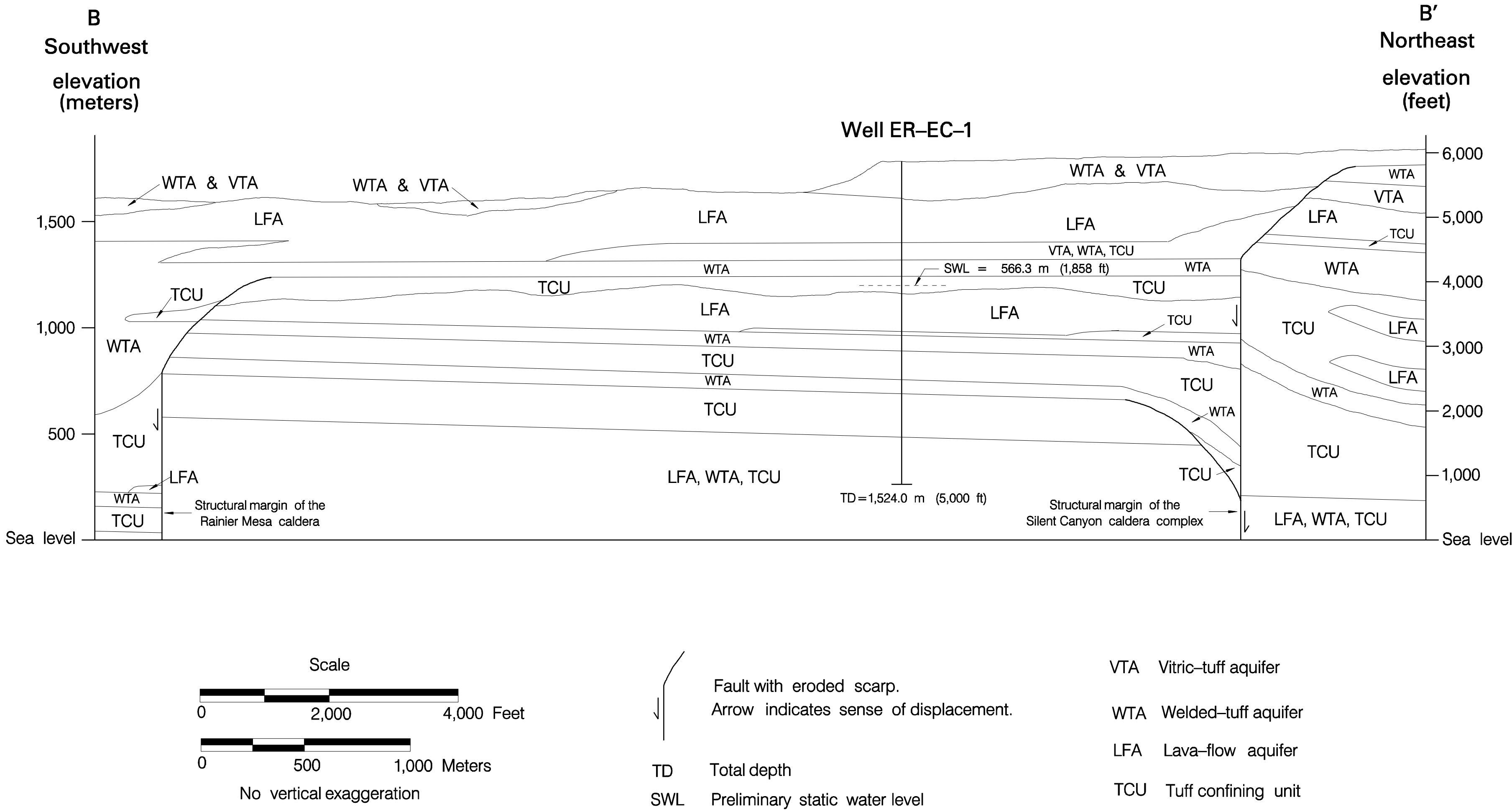

Figure 4-6
Preliminary Hydrogeologic Cross Section B-B' Through Well ER-EC-1

See the discussion of the general hydraulic properties of the hydrogeologic units expected in Well ER-EC-1 in IT (1998), Section A.6.2 and Table A.6.1. Proposed hydrologic testing in the well will verify the actual hydraulic character of the units encountered in Well ER-EC-1.

5.0 Hydrology

5.1 Preliminary Water-Level Information

The elevation of the water table at Well ER-EC-1 was projected to be approximately 1,286 m (4,219 ft), as derived from sparse hydrologic data for this region (IT, 1998). Based on the pre-construction estimate of surface elevation at the site, depth to water was expected at approximately 552 m (1,811 ft) (IT, 1998). Groundwater was first detected (based on dilution of LiBr tracers) at approximately 610.5 m (2,003 ft). During drilling of the hole, the fluid level consistently stabilized at a depth of approximately 566.3 m (1,858 ft), and fluid depths between 564.9 and 569.4 m (1,853.4 and 1,868.0 ft) were obtained from various geophysical logs run between April 20, 1999 and April 22, 1999, before the completion string was installed. After the completion string was set, on May 5, 1999, IT obtained a fluid level in the well of 564.9 m (1,853.4 ft) (IT, written communication, 1999). Based on the composite fluid level of 566.3 m (1,858 ft) and the as-built surface elevation of 1,836.6 m (6,025.6 ft), the fluid level elevation at Well ER-EC-1 is 1,270.3 m (4,167.6 ft). This is approximately 15.7 m (51 ft) below the predicted elevation of 1,286 m (4,219 ft). A transducer was not installed for monitoring of the water level at the time of completion.

5.2 Water Production

Water production was estimated on the basis of LiBr dilution data as measured by IT field personnel. Significant water production began at the depth of approximately 691.9 m (2,270 ft) (IT, written communication, 1999) within lava flows of the rhyolite of Benham. The production rate at first was variable to steady, averaging approximately 946 lpm (250 gpm) until after the Pahute Mesa lobe of Tiva Canyon Tuff was penetrated, below approximately 894.9 m (2,936 ft), when production began steadily to increase. Water production reached a maximum of approximately 2,271 lpm (600 gpm) in lavas of the tuff of Schooner, below the depth of approximately 1,435.6 m (4,710 ft). Estimated water production rates are presented graphically in Appendix A-1. The Rainier Mesa Tuff was expected to be the primary water-producing unit at this location, but was found to be relatively thin, and located above the groundwater level (see Section 4.0).

5.3 Preliminary Thermal Flow Meter Data

Thermal flow meter (TFM) data, along with temperature, electrical conductivity (EC), and pH measurements can characterize borehole fluid variability, which may indicate inflow and outflow zones. These data were used in part to develop the design of the completion string for Well ER-EC-1.

Desert Research Institute (DRI) personnel made TFM measurements at seven locations between the depths of 729.1 and 1,508.8 m (2,392 and 4,950 ft) in Well ER-EC-1 before the completion string was installed. Preliminary analysis of a plot of the discrete TFM data points indicates a slight upward flow of water above a depth of approximately 807.7 m (2,650 ft). Between 807.7 and 1,447.8 m (2,650 and 4,750 ft), the flow becomes downward, ranging between 1.39 and 2.29 lpm (0.367 and 0.604 gpm). The peak downward flow occurs at approximately 975.4 m (3,200 ft) within the mafic-rich Calico Hills Formation, a tuff confining unit. At the depth of 1,508.8 m (4,950 ft), the flow is again upward at 0.67 lpm (0.177 gpm). Plots of the TFM and chemistry log data are reproduced in Appendix D.

In addition, DRI ran a chemistry log, including temperature, EC, and pH, between the depths of 566.6 and 1,517.6 m (1,859 to 4,979 ft). Groundwater temperature gradually increased from the minimum reading of 36.4 degrees Celsius (C) (97.5 degrees Fahrenheit [F]) at the top of the fluid column to the borehole maximum of 71.4 degrees C (160.5 degrees F) at the depth of 1,517.6 m (4,979 ft).

5.4 Radionuclide Monitoring

Samples of fluid from the well were tested for tritium every hour during drilling. These analyses indicated only background levels, and no other man-made radionuclides were encountered during drilling of Well ER-EC-1.

5.5 Preliminary Groundwater Characterization Sample

Following geophysical logging, DRI collected a preliminary groundwater characterization sample from the open borehole at the depth of 762.0 m (2,500 ft). Analytical data from this initial sample, collected before formal well development, will provide a basis for comparison with future groundwater chemistry data.

6.0 Precompletion and Open-Hole Development

The only precompletion development conducted in Well ER-EC-1 consisted of a foam sweep for 20 minutes followed by additional circulation and conditioning of the hole. This process was conducted immediately after TD was reached and prior to geophysical logging.

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7.0 Well Completion

7.1 Introduction

Well completion refers to the installation in a borehole of a string of pipe or casing that is slotted or screened at one or more locations along its length. The completion process also typically includes emplacement of backfill materials around the casing, with coarse fill such as gravel adjacent to the open intervals and impervious materials such as cement between the open intervals to isolate them. The casing serves as a conduit for insertion of a pump in the well, for inserting devices for measuring the fluid level, and for sampling, so that accurate potentiometric and water chemistry data can be obtained from a known portion of the borehole.

Completion activities at Well ER-EC-1 took place on April 23-26, 1999, though the submersible pump will be installed at a later date. Figure 7-1 is a schematic of the final well-completion design for Well ER-EC-1; Table 7-1 is a construction summary for the well; and Figure 7-2 shows a plan view and profile of the wellhead surface completion. Data for this section were obtained from daily operations and activity reports, casing records, and cementing records provided by the BN Drilling Department. Information from IT's well data report (written communication, 1999) was also consulted for preparation of this section.

7.2 Well Completion Design

The final completion design differs slightly from the proposed design, as described in the following paragraphs.

7.2.1 Proposed Completion Design

The original completion design (IT, 1998) was based on the assumption that Well ER-EC-1 would penetrate a thick welded-tuff aquifer of the Rainier Mesa Tuff, and reach TD in rocks of the Paintbrush Group. The well was planned to be completed with a single casing string consisting of 5½-in. stainless steel casing with every other joint slotted, suspended on carbon-steel 7⅝-in. casing. The slotted portion of the well completion string was to extend at least through the welded tuff aquifer of the Rainier Mesa Tuff. If it was determined that the underlying Paintbrush Group rocks comprise sufficient aquifer units, the slotted section would be extended to include these units as well. The proposed completion design also called for the isolation (using non-slotted casing) of low transmissivity zones within the completion interval, if such zones could be identified.

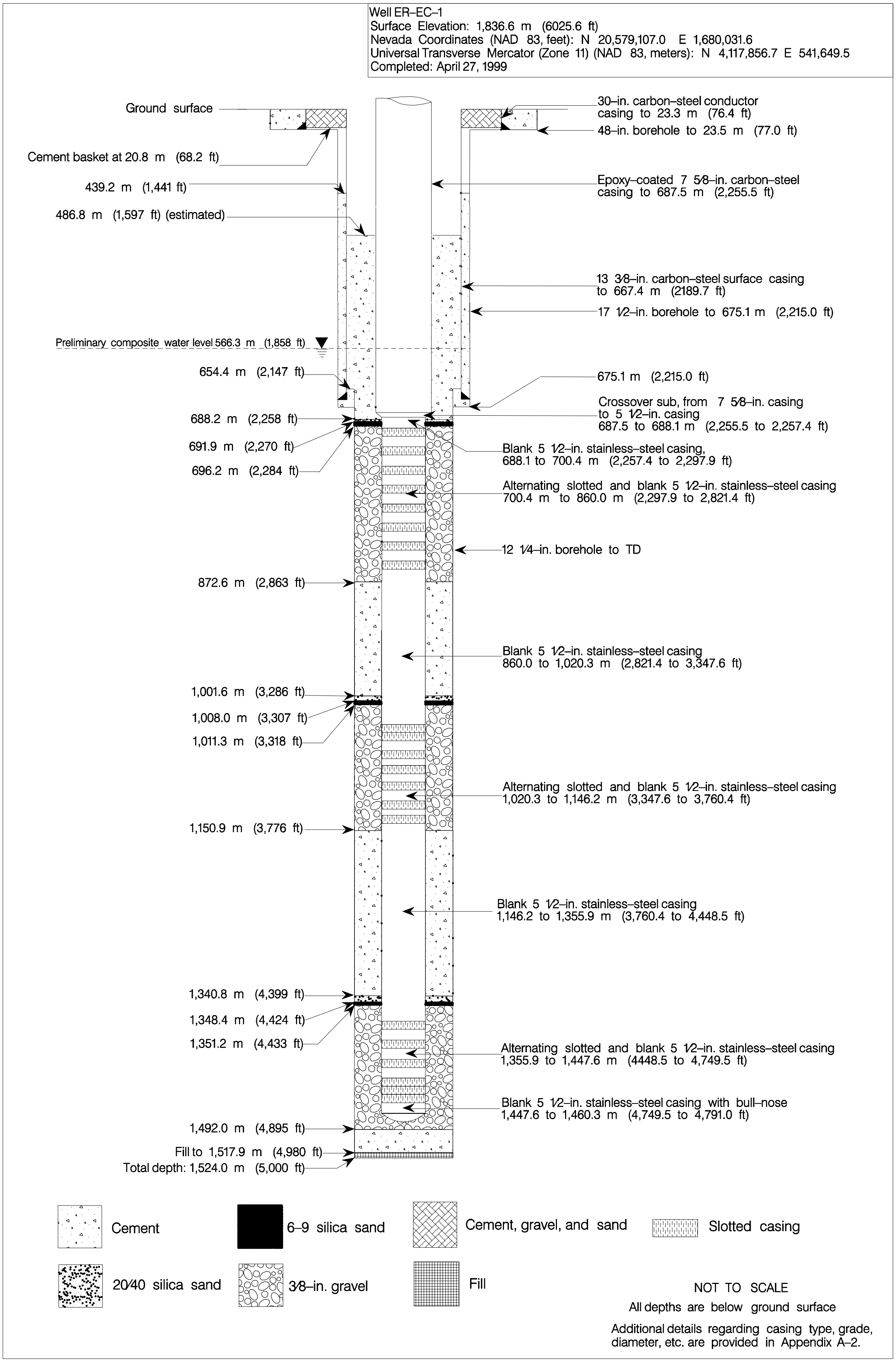


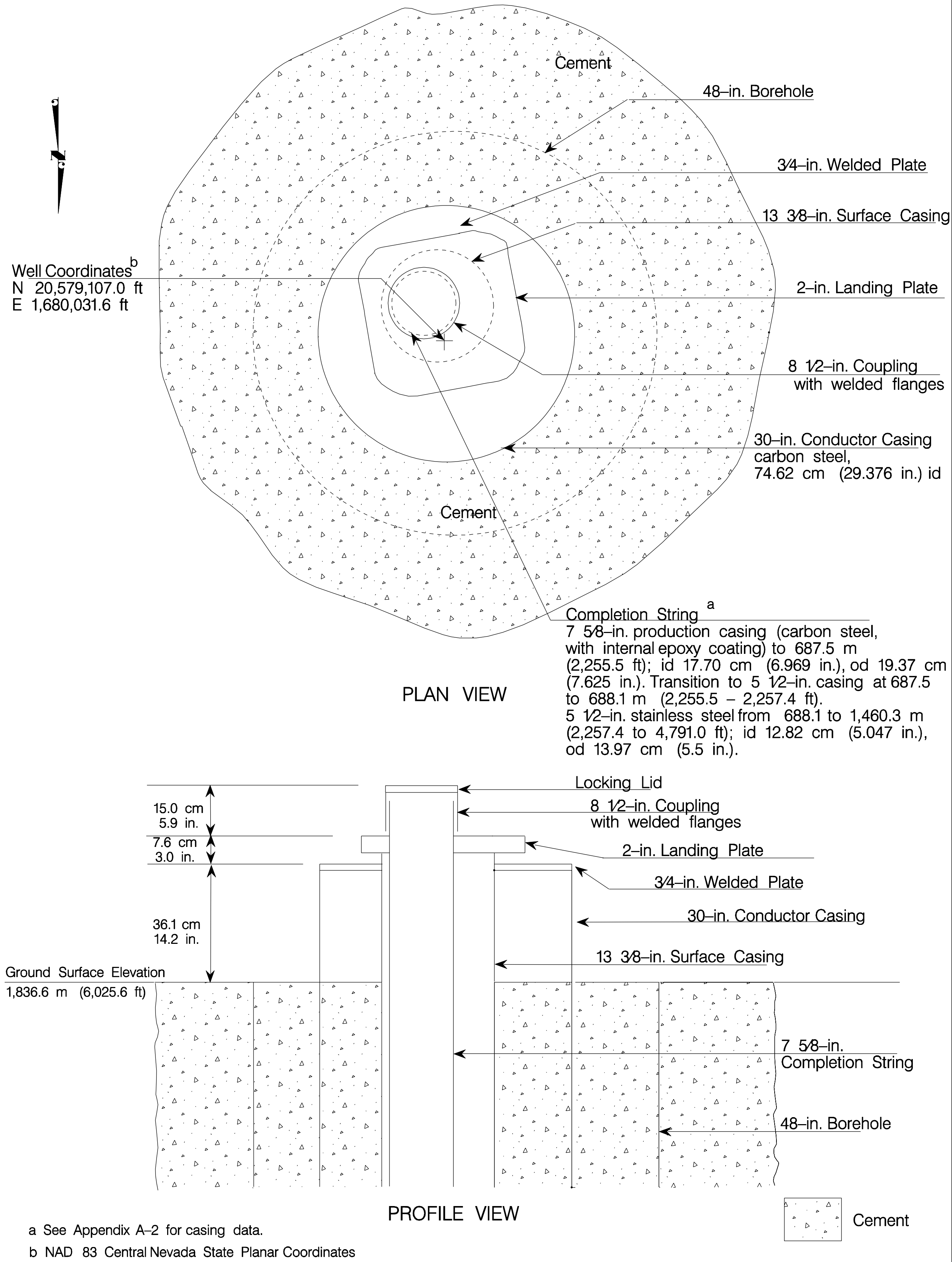
Figure 7-1
As-built Completion Schematic for Well ER-EC-1

Table 7-1
Well ER-EC-1 Completion String Construction Summary

Casing Type	Configuration meters (feet)		Cement	Sand/Gravel
7⅝-in. carbon-steel production casing with internal epoxy coating	0 to 687.5 (0 to 2,255.5)	Blank	Type II 486.8 to 688.2 (1,597 to 2,258)	None
7⅝-in. to 5½-in. crossover sub, carbon-steel, with stainless-steel double pin	687.5 to 688.1 (2,255.5 to 2,257.4)	Blank		
5½-in. Stainless steel production casing	688.1 to 1,518.2 (2,257.4 to 4,980.9)	Blank 687.9 to 700.4 (2,257.0 to 2,297.9)	Type II 872.6 to 1,001.6 (2,863 to 3,286) 1,150.9 to 1,340.8 (3,776 to 4,399) 1,492.0 to 1,517.9 (4,895 to 4,980)	20/40 Sand 688.2 to 691.9 (2,258 to 2,270) 1,008.0 to 1,001.6 (3,286 to 3,307) 1,340.8 to 1,348.4 (4,399 to 4,424) 6-9 Sand 691.9 to 696.2 (2,270 to 2,284) 1,008.0 to 1,011.3 (3,307 to 3,318) 1,348.4 to 1,351.2 (4,424 to 4,433) 3/8-in. x 4 Gravel 696.2 to 872.6 (2,284 to 2,863) 1,011.3 to 1,150.9 (3,318 to 3,776) 1,351.2 to 1,492.0 (4,433 to 4,895)
		8 slotted joints[a] alternating with 8 blank joints 700.4 to 860.0 (2,297.9 to 2,821.4)		
		Blank 860.0 to 1,020.2 (2,821.4 to3,347.6)		
		5 slotted joints[a] alternating with 5 blank joints, overlain by 2 consecutive slotted joints[a] 1,020.2 to 1,146.2 (3,347.6 to 3,760.4)		
		Blank 1,146.2 to 1,355.9 (3,760.4 to 4,448.5)		
		3 slotted joints[a] alternating with 3 blank joints 1,355.9 to 1,420.2 (4,448.5 to 4,659.5)		
		3 slotted joints [b] 1,420.2 to 1,447.6 (4,659.4 to 4,749.5)		
		Blank and bull-nosed 1,447.6 m to 1,460.3 (4,749.4 to 4,791.0)		

a Slots are 0.198 cm (0.078 in.) wide and 5.1 cm (2 in.) long, arranged in 18 rings, on staggered 15.2-cm (6-in.) centers.

b Slots are 0.198 cm (0.078 in.) wide and 5.1 cm (2 in.) long, arranged in 18 rings, on staggered 7.6-cm (3-in.) centers.



a See Appendix A–2 for casing data.

b NAD 83 Central Nevada State Planar Coordinates

Figure 7-2
Wellhead Diagram for Well ER-EC-1

7.2.2 As-Built Completion Design

The design of the Well ER-EC-1 completion was determined through consultation with members of the UGTA TWG, on the basis of on-site evaluation of data such as lithology and water production, drilling data (lost circulation, etc.), data from geophysical logs (particularly caliper, down-hole video, acoustic fracture log), and from thermal-flow and water chemistry logs. The final completion design was documented in a BN Record of Verbal Communication (Bangerter, 1999).

The as-built completion design for Well ER-EC-1 provides access to three potential aquifers (Figure 7-1). The composition of the string summarized here is detailed on Table 7-1, and the casing materials are listed in Appendix A-2. The lower section of the completion string, from 1,460.3 to 668.0 m (4,790.9 to 2,257.4 ft), is type T304L stainless-steel casing with an outside diameter of 14.0 cm (5.5 in.) and an inside diameter of 12.819 cm (5.047 in.). The top of the 5½-in. casing is approximately 121.6 m (400 ft) below the static fluid level. The bottom 0.27-m (0.9-ft) joint is a blank bull-nose to serve as a sediment sump. Above the 5½-in. casing, a 0.6-m (2.0-ft) long crossover sub serves as the transition to the upper part of the string, which is 7⅝-in. carbon-steel production casing with an internal epoxy coating.

The lowest screened interval is open to a series of alternating lava-flow aquifers and tuff confining units of the tuff of Schooner and the lower biotite-bearing rhyolite of Quartz Mountain (See Figure 4-2 for an illustration of gravel-pack locations relative to hydrogeologic units.). This casing interval consists of three slotted joints alternating with three blank joints, underlain by three consecutive slotted joints. The second slotted interval, 1,020.3 to 1,146.2 m (3,347.6 to 3,760.4 ft) is open to a welded-tuff aquifer of the Prow Pass Tuff (and tuff confining units assigned to the Calico Hills Formation and the Stockade Wash lobe of the Bullfrog Tuff), and consists of five slotted joints alternating with five blank joints, overlain by two consecutive slotted joints. The uppermost slotted interval, 700.4 to 695.4 m (2,297.9 to 2,281.4 ft), consists of eight slotted joints alternating with eight blank joints, and is open to the lava-flow aquifer of the rhyolite of Benham and the welded-tuff aquifer of the Pahute Mesa lobe of Tiva Canyon Tuff.

The openings in each slotted casing joint are 0.198 cm (0.078 in.) wide and 5.1 cm (2 in.) long, arranged in 18 rings. On all but the three deepest joints the slots are on staggered 15.2-cm (6-in.) centers. On the three casing joints installed between 1,420.2 and 1,447.6 m (4,659.4 and 4,749.5 ft), the slots are on staggered 7.6-cm (3-in.) centers.

7.2.3 Rationale for Differences between Actual and Proposed Well Design

Instead of the thick section of saturated welded Rainier Mesa Tuff expected, several thinner welded-tuff aquifers and lava-flow aquifers were encountered in Well ER-EC-1. The completion design was modified as necessary to address this more complicated hydrogeologic setting, with at least three potential water-producing zones alternating with confining units. However, the basic plan of installing a single string consisting of larger diameter carbon-steel casing above the water table and smaller diameter stainless-steel casing in the saturated zone was accomplished.

7.3 Well Completion Method

A "tremie" line and the completion string were landed after a brief period of circulation and conditioning of the hole. The three completion zones were gravel-packed and then isolated from each other with sand and cement barriers. Caliper logs were used to calculate the volumes of cement needed during well completion. Well-construction materials were inspected in accordance with relevant procedures; standard decontamination procedures were employed to prevent the introduction of contaminants into the well.

The filter pack around each open interval consists of 0.95-cm (⅜-in.) by 4-mesh washed gravel, with 6-9 Colorado silica sand directly above the gravel, and 20/40 silica sand on top of the 6-9 sand. In this stemming design, developed by the UGTA program at the NTS, the layer of 20/40 sand absorbs any fluids that might seep from the cement above, preventing cement fluids from contaminating the groundwater (fluids from the cement would have the effect of drastically raising the pH of the groundwater). The underlying layer of 6-9 sand prevents the 20/40 sand from infiltrating the gravel-packed interval. All cement used was Type II Portland cement with no additives. A clear-water pre-flush and back-flush were made at each stage of emplacement. Gravel, sand, and cement were emplaced through a 2⅞-in. Hydril® tremie line that was withdrawn as the completion process progressed. A nuclear annulus investigation log was used to monitor the emplacement of stemming materials. As-built positions of the well materials are shown on Figure 7-1 and listed in Table 7-1.

Stemming of the hole began with the first stage of Portland Type II cement emplaced from 1,517.9 to 1,492.0 m (4,980 to 4,895 ft) on top of 6.1 m (20 ft) of fill at the bottom of the hole. The lowest gravel-pack was placed on top of the cement, from 1,492.0 to 1,351.2 m (4,895 to 4,433 ft), outside the first slotted interval. This gravel pack is topped by a sand barrier to 1,340.8 m (4,399 ft), followed by cement, poured in two stages up to 1,150.9 m (3,776 ft). The second gravel-pack was placed between 1,150.9 and 1,008.0 m (3,776 and 3,307 ft), and was topped with sand to 1,001.6 m (3,286 ft) and cement to 872.6 m (2,863 ft). The uppermost gravel-pack is located between 872.6 and 696.2 m (2,863 and 2,284 ft), and is capped with a sand barrier to 688.2 m (2,258 ft); the final cemented section extends to 486.8 m (1,597 ft).

The drill rig was released after cementing was completed. Because a pump was not installed in the well, no well-development or pumping tests were conducted immediately after completion.

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8.0 Actual versus Planned Costs and Scheduling

The BN cost model developed for the 1,524-m (5,000-ft) wells in the WPM-OV drilling program baseline projected that it would require 53 days to accomplish drilling, logging, and completion for each well. The actual time spent (after rigging up) on drilling and completion of Well ER-EC-1 was only 24 days, in part because no intermediate casing was required. A graphical comparison, by day, of planned and actual well-construction activities is presented in Figure 8-1.

The cost analysis for Well ER-EC-1 begins with the construction of the conductor hole by BN. The cost of building roads, the drill pad, and sumps is not included, and the cost of well-site support by IT is not included. The construction cost for Well ER-EC-1 includes all drilling costs: charges by the drilling subcontractor; charges by other support subcontractors (including compressor services, drilling fluids, bits, casing services, down-hole tools and down-hole camera services, and geophysical logging); and charges by BN for mobilization and demobilization of equipment, construction of the conductor hole, cementing services, completion materials, radiation technicians, inspection services, and geotechnical consultation.

The total planned cost for Well ER-EC-1 was $2,327,248. The actual cost was $2,166,671, or approximately 7 percent less than the planned cost. Figure 8-2 is a comparison of the planned and actual costs, by day, for drilling and completing Well ER-EC-1.

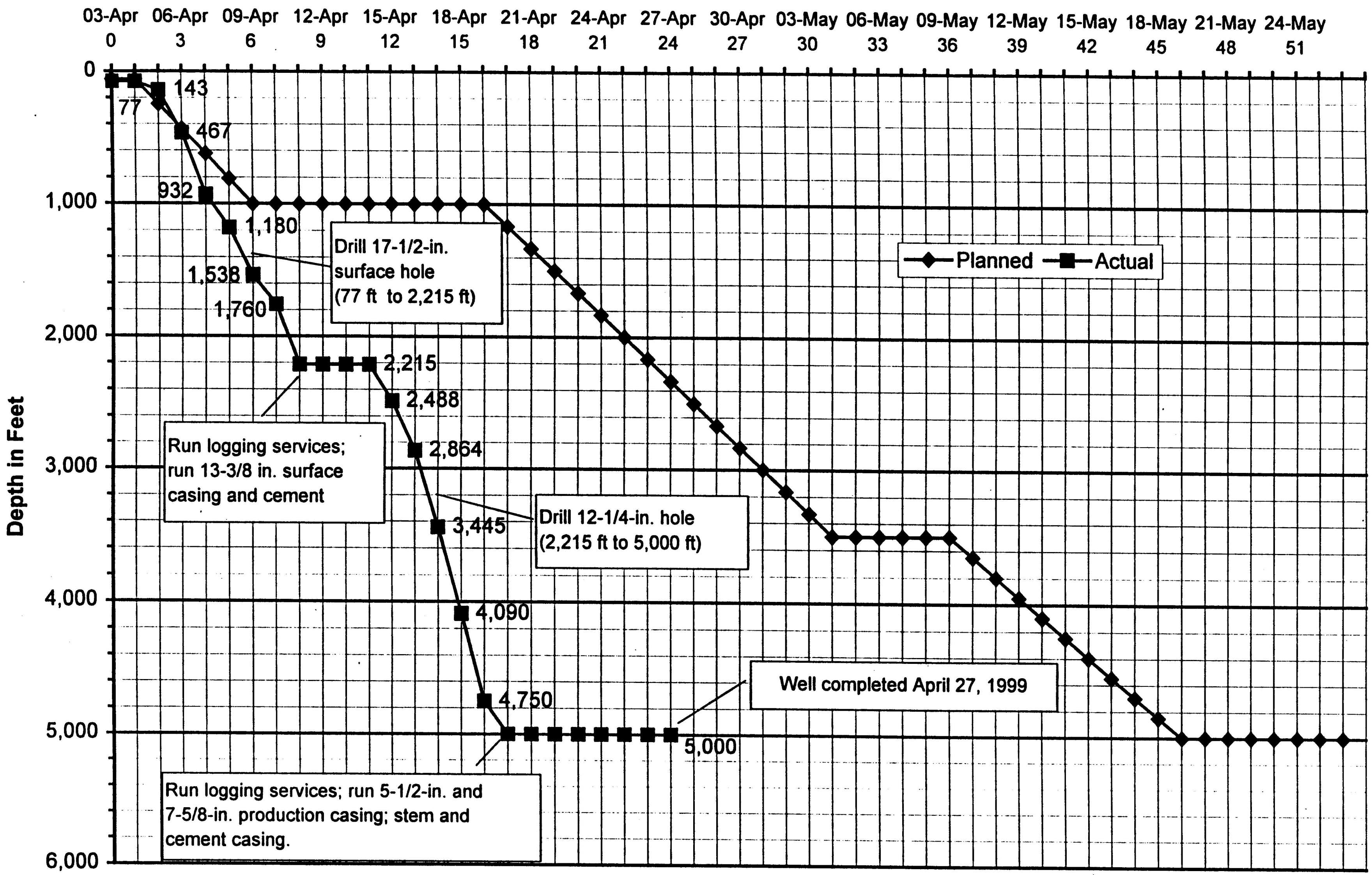

Figure 8-1
Planned versus Actual Drilling Progress for Well ER-EC-1

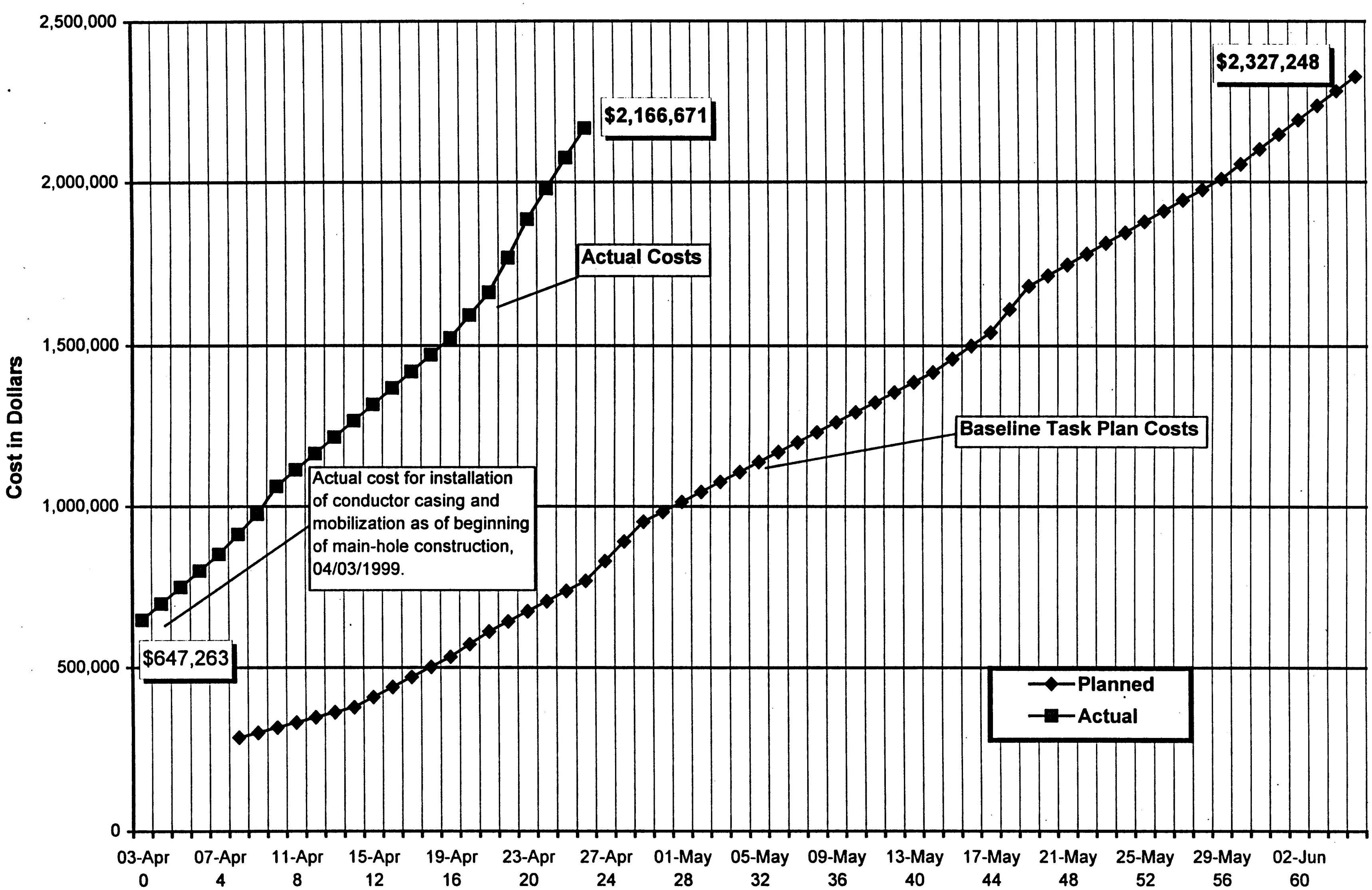

Figure 8-2
Planned versus Actual Costs for Drilling Well ER-EC-1

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9.0 Summary, Recommendations, and Lessons Learned

9.1 Summary

Drilling of the main hole at Well ER-EC-1 commenced on April 4, 1999, and concluded on April 27, 1999, when the planned TD of 1,524.0 m (5,000 ft) was reached. After geophysical logging, the completion string was installed and gravel-packed, and the hole was cemented to 486.8 m (1,597 ft) on April 24-27, 1999. Crews worked on a 7-days-a-week, 24-hours-a-day schedule for most of the operation. Twenty-four working days were expended on drilling, logging, and completion activities. No significant problems were encountered during construction of Well ER-EC-1.

No radionuclides above background were encountered in the groundwater produced from Well ER-EC-1. The static fluid level consistently stabilized at the depth of approximately 566.3 m (1,858 ft) during drilling. IT personnel obtained a fluid level of 564.9 m (1,853.4 ft) on May 10, 1999, two weeks after the completion string was installed.

Composite drill cuttings were collected every 3 m (10 ft) from 21.3 m (70 ft) to TD. Thirty-one sidewall core samples were collected in the interval 680.6 to 1,503.6 m (2,233 to 4,933 ft). Geophysical logging was conducted in the upper part of the hole before installation of the surface casing, and in the lower part of the hole before installation of the completion string. Some of these logs were used to aid in construction of the well, while others help to verify the geology and determine the hydrologic characteristics of the rocks.

A single completion string, with three gravel-packed, slotted intervals, was installed in Well ER-EC-1. A string of 5½-in. stainless-steel casing installed below the water table, is suspended from 7⅝-in. carbon-steel casing (with an internal epoxy coating) which extends to the surface. The open intervals in the 5½-in. casing are centered within the gravel-pack intervals located at 696.2 to 872.6 m (2,284 to 2,863 ft); 1,011.3 to 1,150.9 m (3,318 to 3,776 ft); and 1,351.2 to 1,492.0 m (4,433 to 4,895 ft). These intervals are open to welded-tuff aquifers and lava-flow aquifers of the rhyolite of Benham and Pahute Mesa lobe of Tiva Canyon Tuff; Prow Pass Tuff; and tuff of Schooner and rhyolite of Quartz Mountain, respectively.

9.2 Recommendations

The planned pump installation, well development, groundwater sampling, and hydrologic testing must be conducted at Well ER-EC-1 to accomplish the remaining objectives for this well-construction effort. Mineralogic and chemical analyses of rock samples, which are currently in progress, must be completed and evaluated for preparation of the final interpretation of the well geology. In addition, after all the planned WPM-OV wells are drilled, geologic and hydrologic data must be evaluated and interpretations of the area hydrogeology updated for insertion into the UGTA hydrologic model. This process, followed by analysis of the updated model, will allow more precise characterization of groundwater flow direction and velocity in the region between the nuclear testing areas of Pahute Mesa and the Oasis Valley discharge area.

9.3 Lessons Learned

Although very few problems were encountered during construction of Well ER-EC-1, one lesson was learned regarding estimation of water production. It was found that when water production is high, greater concentrations of the LiBr tracer should be added to the drilling fluid. This will permit more accurate calculation of dilution rates, leading to better estimation of groundwater production.

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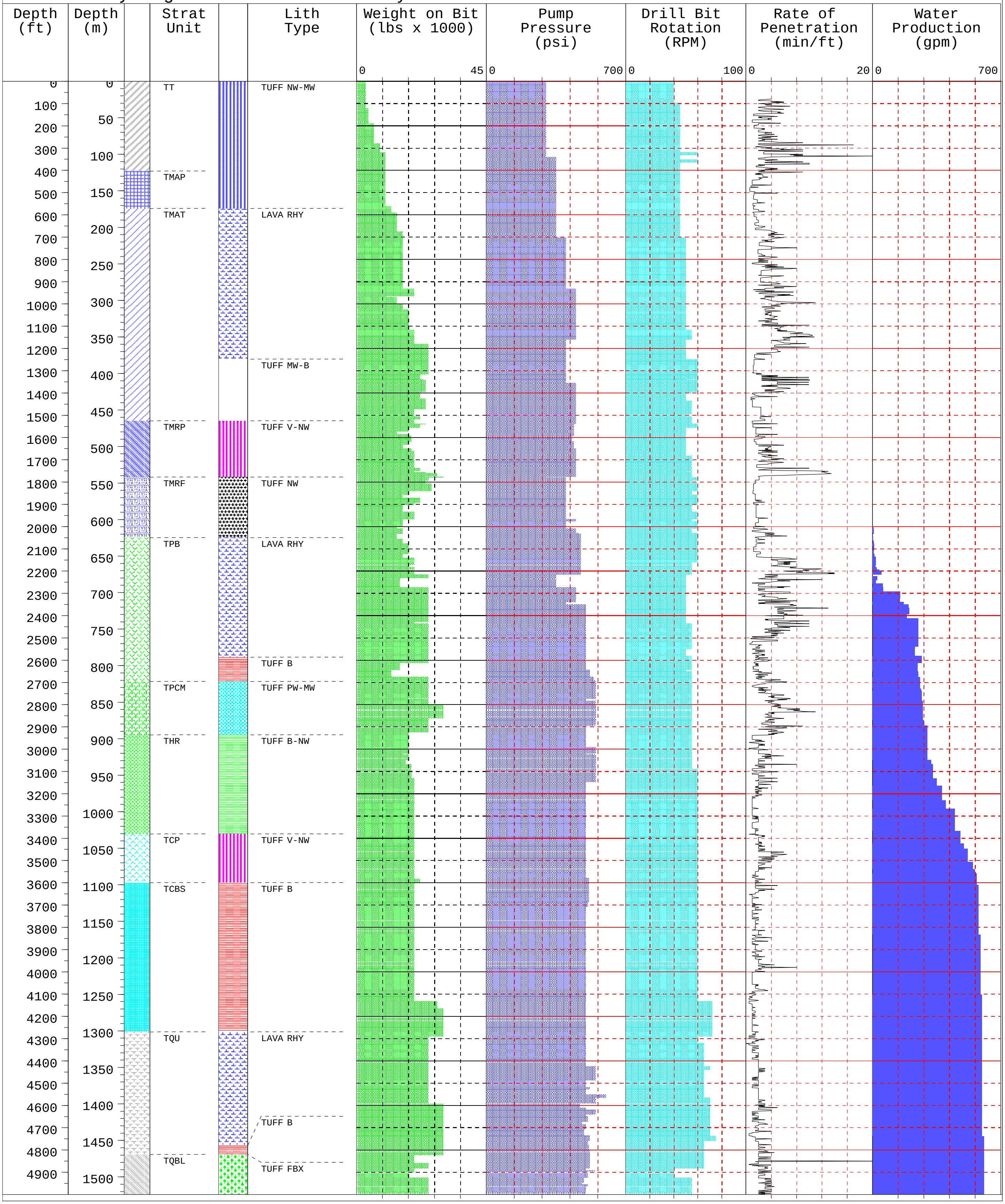
Appendix A
Drilling Data

A-1 Drilling Parameter Logs for Well ER-EC-1
A-2 Casing Data for Well ER-EC-1
A-3 Well ER-EC-1 Drilling Fluids and Cement Composition

Appendix A-1
Drilling Parameter Logs for Well ER-EC-1

Well Name: ER-EC-1	Western Pahute Mesa - Oasis Valley Drilling Program		Northing: 4117856.7 m
Date: 7/29/99	Start Date: 4/4/99	Stop Date: 4/27/99	Easting: 541649.5 m
Environmental Contractor: UGTA/IT		Proj No: 776706.02.08.02.02	Surface Elevation: 6025.6 ft
Drilling Contractor: United	Drilling Method: Air Foam	Geol: J. Wurtz	Depth: 5000.00 ft.

Preliminary Log for Information Only



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Appendix A-2
Casing Data for Well ER-EC-1

Casing Data for Well ER-EC-1

CASING	**Depth Interval** meters (feet)	Type	Grade	**Outside Diameter** centimeters (inches)	**Inside Diameter** centimeters (inches)	**Wall Thickness** centimeters (inches)	**Weight per foot** (pounds)
Conductor Casing	0 to 23.3 (0 to 76.4)	Carbon Steel PE Weld	A	76.20 (30)	74.295 (29.250)	0.953 (0.375)	118.7
Surface Casing	0 to 667.4 (0 to 2,189.7)	Carbon Steel	K5	33.97 (13.375)	32.042 (12.615)	0.965 (0.380)	54.5
Completion Casing (with crossover)	0 to 688.1 (0 to 2,257.4)	Carbon Steel with internal epoxy coating	N80	19.37 (7.625)	17.701 (6.969)	0.833 (0.328)	26.4
Completion Casing	688.1 to 1,460.0 (2,257.4 to 4,791.0)	Stainless Steel	T304L	13.97 (5.5)	12.819 (5.047)	0.577 (0.227)	14.6

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Appendix A-3
Well ER-EC-1 Drilling Fluids and Cement Composition

Table A-3-1
Well ER-EC-1 Drilling Fluids

Air-Foam (Typical [a])	**Air-Foam/Polymer** (Typical [b])
0.011 m^3 [c] (3 gal [d]) Acrylafoam [f] per 7.9 m^3 (50 bbls [e]) water	0.015 to 0.030 m^3 (4 - 8 gal) Acrylafoam and 0.011 to 0.015 m^3 (3 - 4 gal) Acrylavis [f] per 7.9 m^3 (50 bbls) water

a Air-foam was used as the drilling fluid between approximately 23.5 and 91.4 m (77 to 300 ft).
b Various proportions of polymer were added to suit conditions during air-foam drilling below approximately 91.4 m (300 ft).
c Cubic meters
d Gallons
e Barrels
f Acrylafoam and Acrylavis are products of Enterprise Drilling Fluids, Inc.

NOTES:
1. All water used to mix drilling fluids for Well ER-EC-1 came from Water Well 20.
2. A concentrated solution of lithium bromide was added to all introduced fluids to make up a final concentration of 17 to 27 milligrams per liter.

Table A-3-2
Well ER-EC-1 Cement Composition

Cement Composition	**66-in.[a] Temporary Conductor Casing**	**30-in. Conductor Casing**	**13⅜-in. Surface Casing**	**Completion**
Redi-Mix	0 to 0.8 m [b] (0 to 2.5 ft [c])	0 to 23.5 m (0 to 77 ft)	Not used	Not used
Type II plus sand	Not used	Not used	Above cement baskets 17.7 to 19.5 m (58 to 64 ft)	Not used
Type II	Not used	Not used	0 to 17.7 m (0 to 58 ft) 19.5 to 20.7 m (64 to 68 ft) 439.2 to 675.1 m (1,441 to 2,215 ft)	486.8 to 688.2 m (1,597[d] to 2,258 ft) 872.6 to 1,001.6 m (2,863 to 3,286 ft) 1,150.9 to 1,340.8 m (3,776 to 4,399 ft) 1,492.0 to 1,517.9 m (4,895 to 4,980 ft)

a inch b meter(s) c foot (feet) d estimated

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Appendix B
Well ER-EC-1 Fluid Management Data

FLUID DISPOSITION REPORTING FORM

Site Identification: ER-EC-1
Site Location: Nellis Air Force Range
Site Coordinates: N 4,117,659.67m E 541,730.31m
Well Classification: ER Hydrogeologic Investigation Well
IT Project No: 776706-02-08-02-02

Report Date: 4/21/1999
DOE/NV Subproject Manager: Bob Bangerter
IT Project Manager: Janet Wille
IT Site Representative: Jeff Wurtz
IT Environmental Specialist: Patty Gallo

Well Construction Activity	Activity Duration		#Ops. Days [a]	Well Depth (m)	Import Fluid (m^3)	Sump #1 Volumes (m^3)		Sump #2 Volumes (m^3)		Infiltration Area (m^3) [d]	Other [c] (m^3)	Fluid Quality Objectives Met?
	From	To				Solids [b]	Liquids	Solids	Liquids	Liquids		
Phase I: Vadose-Zone Drilling	4/4/99	4/10/99	7	565.7	661.4	149.2	390.09	-	-	-	n/a	Y
Phase I: Saturated-Zone Drilling	4/10/99	4/19/99	8	1,524	1,323	30.11	138.08	91.26	9,127.07	-	n/a	Y
Phase II: Initial Well Development	Pending	Pending	-	-	-	-	-	-	-	-	-	-
Phase II: Aquifer Testing	Pending	Pending	-	-	-	-	-	-	-	-	-	-
Phase II: Final Development	Pending	Pending	-	-	-	-	-	-	-	-	-	-
Cumulative Production Totals to Date:			15	1,524	1,984.4	179.31	528.17	91.26	9,127.07	-	-	Y

[a] Operational days refer to the number of days that fluids were produced during at least part (>3 hours) of one shift.
[b] Solids volume estimates include calculated added volume attributed to rock bulking factor.
[c] Other refers to fluid conveyance to other fluid management locations or facilities away from the well site, such as vacuum truck transport to another well site.
[d] Ground surface discharge and infiltration to a natural surface

NA = Not Applicable; m = meters; m^3 = cubic meters; AIP = Analysis In Process
Total Facility Capacities: Sump #1 = 1,089 m^3 Sump #2 = 10,905 m^3

Infiltration Area (assuming very low/no infiltration) = ____ m^3

Remaining Facility Capacity (Approximate) as of 4/21/99: Sump #1 = 115 m^3 (11 %) Sump #2 = 1,629 m^3 (15 %)

Current Average Tritium = (Natural Background) pCi/L
Notes: Activity Duration for Phase I and Phase II included drilling and subsequent reaming

IT Authorizing Signature/Date: [signature] 4-21-99

LV\6-23-99\forms\form_158

Preliminary Analytical Results for Fluid Management Samples: Well ER-EC-1

Sample Number	Date & Time Collected	Comment		RCRA Metals (mg/L)								Gross Alpha (pCi/L)	Gross Beta (pCi/L)	Tritium (pCi/L)
				Arsenic	Barium	Cadmium	Chromium	Lead	Selenium	Silver	Mercury			
EC-1-04149-2	04/14/1999 22:50	Sample collected from unlined sump	Total [a]	0.002	0.0065	0.0002	0.0068	0.001	0.0022	0.0005	0.00002	12.5	5.91	-163
			Dissolved [b]	0.002	0.001	0.0002	0.0035	0.0009	0.0022	0.00054	0.00002	NA	NA	NA
EC-1-04279-1	04/27/1999 08:33	Sample collected from unlined sump	Total	0.0067	0.0381	0.0002	0.0165	0.0089	0.0022	0.0005	0.00002	9.42	5.15	-169
			Dissolved	0.004	0.0031	0.0002	0.0123	0.0009	0.0022	0.001	0.00002	NA	NA	NA
EC-1-04279-2	04/27/1999 09:16	Sample collected from lined sump	Total	0.0051	0.0392	0.0002	0.0049	0.0056	0.0022	0.00064	0.00002	16.6	4.44	349
			Dissolved	0.0044	0.0034	0.0002	0.0018	0.0009	0.0022	0.00064	0.00002	NA	NA	NA
Nevada Drinking Water Standard (NDWS)				0.05	2.0	0.005	0.1	0.015	0.05	0.1	0.002	15	50	20,000
5 Times NDWS				0.25	10	0.025	0.5	0.075	0.25	0.5	0.01	75	250	100,000

a Initial analysis for total RCRA metals.
b Analysis of dissolved RCRA metals on a resubmitted sample fraction.

Data provided by IT (written communication, 1999).

RCRA = Resource Conservation and Recovery Act of 1976
NA = not analyzed
QA/QC = quality assurance and quality control
mg/L = milligrams per liter
pCi/L = picocuries per liter

Appendix C
Preliminary Detailed Lithologic Log for Well ER-EC-1

Preliminary Detailed Lithologic Log for Well ER-EC-1

Logged by L. B. Prothro (BN Geology) and R. G. Warren (LANL)

July 7, 1999

Depth Interval meters (feet)	**Thickness** meters (feet)	**Sample Type** [a]	**Laboratory Analyses** [b]	**Lithologic Description** [c]	**Stratigraphic Unit** [d]
0 - 4.9 (0 - 16)	4.9 (16)	DA	None	**Moderately Welded Ash-Flow Tuff:** Grayish brown (5YR 3/2) and dusky brown (5YR 2/2); devitrified; minor dark-yellowish-brown (10YR 2/2) pumice; minor feldspar phenocrysts; rare olivine; rare lithic fragments.	Ttt
4.9 - 23.2 (16 - 76)	18.3 (60)	None	None	**Bedded Tuff:** Probably vitric. Geology inferred from drilling characteristics and nearby surface exposures.	
23.2 - 123.1 (76 - 404)	100.0 (328)	DA, DB1	None	**Nonwelded and Partially Welded Ash-Flow Tuff and minor Bedded Tuff:** Samples consist of a mixture of loose fragments of nonwelded to moderately welded ash-flow tuff and crystals of feldspar. Most of the ash-flow tuff fragments have rare to minor feldspar phenocrysts and no biotite. The interval appears to be mostly devitrified in the upper portion, and mostly vitric lower.	Ttp/Ttr
123.1 - 129.8 (404 - 426)	6.7 (22)	DB1	None	**Nonwelded Ash-Flow Tuff:** Dark-yellowish-orange (10YR 6/6); vitric; abundant dusky-brown (5YR 2/2), dark-yellowish-orange (10YR 6/6), and white (N9) pumice; minor felsic phenocrysts of feldspar, including chatoyant sanidine, and much less quartz; minor mafic minerals of biotite and lesser clinopyroxene; rare lithic fragments.	Tmap
129.8 - 165.8 (426 - 544)	36.0 (118)	DA	None	**Partially Welded Ash-Flow Tuff:** Grayish orange pink (5YR 7/2); devitrified, with vapor-phase mineralization; common very-light-gray (N8) pumice; minor felsic phenocrysts of feldspar, including chatoyant sanidine, and lesser quartz; minor mafic minerals of biotite and much less clinopyroxene; rare lithic fragments; sphene is present.	

Depth Interval meters (feet)	Thickness meters (feet)	Sample Type [a]	Laboratory Analyses [b]	Lithologic Description [c]	Stratigraphic Unit [d]
165.8 - 174.3 (544 - 572)	8.5 (28)	DA	None	**Nonwelded Ash-Flow Tuff:** Moderate brown (5YR 4/4); vitric; minor very-pale-orange (10YR 8/2) and dark-yellowish-orange (10YR 6/6) pumice; minor felsic phenocrysts of feldspar, including chatoyant sanidine, and lesser quartz; rare biotite; rare lithic fragments; abundant dark-yellowish-orange (10YR 6/6) glass shards.	Tmap
174.3 - 198.1 (572 - 650)	23.8 (78)	DA	None	**Pumiceous Lava:** Pale yellowish brown (10YR 6/2); vitric; weakly perlitic; minor felsic phenocrysts of feldspar and quartz; rare biotite; sphene is present.	Tmat
198.1 - 245.7 (650 - 806)	47.5 (156)	DA	None	**Lava:** Grayish brown (5YR 3/2); devitrified and silicic, partially vitric in places; spherulitic and flow banded, weakly pumiceous and weakly perlitic in places; minor felsic phenocrysts of quartz and feldspar; rare biotite; fragments of botryoidal chalcedony are present in samples; sphene is present.	
245.7 - 340.2 (806 - 1,116)	94.5 (310)	DA	None	**Lava:** Light brownish gray (5YR 6/1); mostly devitrified, partially silicic; weakly pumiceous, spherulitic in upper part; minor felsic phenocrysts of quartz and feldspar; rare rust-colored biotite; altered sphene is present.	
340.2 - 349.3 (1,116 - 1,146)	9.1 (30)	DA	PS, MP, XRD, XRF, Fe^{2+}/Fe^{3+}	**Vitrophyric Lava:** Grayish black (N2); vitric; perlitic; minor felsic phenocrysts of quartz and feldspar; rare biotite; altered sphene is present.	
349.3 - 360.9 (1,146 - 1,184)	11.6 (38)	DA	None	**Vitrophyric Lava**: Brownish black (5YR 2/1); mostly devitrified, partially vitric; perlitic; minor felsic phenocrysts of quartz and feldspar; rare biotite; altered sphene is present.	
360.9 - 380.4 (1,184 - 1,248)	19.5 (64)	DA	None	**Pumiceous Lava:** Moderate reddish brown (10R 4/6); mostly vitric, partially devitrified; minor felsic phenocrysts of quartz and feldspar; rare biotite; sphene is present.	

Depth Interval meters (feet)	Thickness meters (feet)	Sample Type [a]	Laboratory Analyses [b]	Lithologic Description [c]	Stratigraphic Unit [d]
380.4 - 399.9 (1,248 - 1,312)	19.5 (64)	DA	None	**Bedded Tuff:** Moderate reddish orange (10R 6/6); mostly devitrified, partially vitric; common grayish-orange-pink (10R 8/2) pumice; rare felsic phenocrysts of quartz and feldspar; rare biotite; rare lithic fragments; sphene is present.	Tmat
399.9 - 413.3 (1,312 - 1,356)	13.4 (44)	DA	None	**Moderately Welded Ash-Flow Tuff:** Grayish brown (5YR 3/2); vitric; weakly perlitic; common clear to very-light-gray (N8) silicic pumice; minor felsic phenocrysts of quartz and lesser feldspar; rare biotite; trace of sphene.	Tmat
413.3 - 424.9 (1,356 - 1,394)	11.6 (38)	DA	PS, MP, XRD, XRF, Fe^{2+}/Fe^{3+}	**Moderately Welded Ash-Flow Tuff:** Moderate reddish brown (10YR 4/6); vitric and devitrified; minor pale-yellowish-brown (10YR 6/2) pumice; minor felsic phenocrysts of quartz and lesser feldspar; rare biotite; trace of sphene.	Tmat
424.9 - 464.8 (1,394 - 1,525)	39.9 (131)	DA	None	**Bedded Tuff:** Light brown (5YR 6/4) to 448.1 m (1,470 ft), becoming very pale orange (10YR 8/2) below; zeolitic; minor yellowish-gray (5Y 8/1) and moderate-yellow (5Y 7/6) pumice; minor felsic phenocrysts of feldspar and conspicuous dipyramidal quartz; minor biotite; rare lithic fragments; altered sphene is present.	Tmat
464.8 - 470.6 (1,525 - 1,544)	5.8 (19)	DB2	None	**Nonwelded Ash-Flow Tuff:** Interval not represented in cuttings. Geology inferred from geophysical logs.	Tmrp
470.6 - 477.9 (1,544 - 1,568)	7.3 (24)	DA	None	**Partially Welded Ash-Flow Tuff:** Pale red (10R 6/2); devitrified; minor very-light-gray (N8) and light-greenish-gray (5GY 8/1) pumice; common felsic phenocrysts of feldspar and quartz; minor biotite; rare lithic fragments.	Tmrp
477.9 - 513.9 (1,568 - 1,686)	36.0 (118)	DA	PS, MP, XRD, XRF, Fe^{2+}/Fe^{3+}	**Moderately Welded Ash-Flow Tuff:** Light brownish gray (5YR 6/1); devitrified; minor very-light-gray (N8) pumice; common felsic phenocrysts of feldspar and quartz; minor mafic minerals of bronze biotite and metallic pseudomorphs after clinopyroxene; rare lithic fragments.	Tmrp

Depth Interval meters (feet)	Thickness meters (feet)	Sample Type [a]	Laboratory Analyses [b]	Lithologic Description [c]	Stratigraphic Unit [d]
513.9 - 530.4 (1,686 - 1,740)	16.6 (54)	DA	None	**Densely Welded Ash-Flow Tuff:** Light brown (5YR 5/6) to 521.8 m (1,712 ft), becoming mottled grayish red (10R 4/2) and light brown (5YR 5/6) below; devitrified and silicic, becoming quartzo-feldspathic in part below 521.8 m (1,712 ft); poorly developed honeycomb texture present below 521.8 m (1,712 ft); common felsic phenocrysts of feldspar and quartz; minor biotite; rare lithic fragments. The characteristics observed below 521.8 m (1,712 ft), such as mottled color, quartzo-feldspathic alteration, and honey-comb texture, are likely the result of mild hydrothermal alteration, possibly related to a fault cutting the borehole in the vicinity of this interval.	Tmrp
530.4 - 541.9 (1,740 - 1,778)	11.6 (38)	DA	PS, MP, XRD, XRF, Fe^{2+}/Fe^{3+}	**Vitrophyric Ash-Flow Tuff:** Black (N1) to brownish black (5YR 2/1); vitric; perlitic; minor felsic phenocrysts of feldspar and quartz; rare biotite. Geophysical logs show an abrupt decrease in welding below 537.7 m (1,764 ft).	
541.9 - 624.8 (1,778 - 2,050)	82.9 (272)	DA	PS, MP, XRD, XRF, Fe^{2+}/Fe^{3+}	**Nonwelded Tuff:** Light brown (5YR 6/4) and moderate reddish orange (10R 6/6); zeolitic; common grayish-orange-pink (10R 8/2) pumice; rare felsic phenocrysts of feldspar and quartz; minor biotite; rare lithic fragments.	Tmrf
624.8 - 687.6 (2,050 - 2,256)	62.8 (206)	DA, SC	PS, MP, XRD, XRF, Fe^{2+}/Fe^{3+}	**Lava:** Yellowish gray (5Y 7/2) and grayish yellow (5Y 8/4); zeolitic, becoming partially silicic below 664.5 m (2,180 ft); pumiceous in upper portion, spherulitic below 664.5 m (2,180 ft), remnant perlitic texture; rare feldspar phenocrysts; rare biotite; altered sphene is present.	Tpb
687.6 - 759.9 (2,256 - 2,493)	72.2 (237)	DA, SC	None	**Lava:** Mottled pale reddish brown (10R 5/4), pale brown (5YR 5/2), light gray (N7), and medium dark gray (N4); devitrified and silicic; very spherulitic in upper part, weakly flow banded; rare feldspar phenocrysts; minor biotite; sphene is present.	

Depth Interval meters (feet)	Thickness meters (feet)	Sample Type [a]	Laboratory Analyses [b]	Lithologic Description [c]	Stratigraphic Unit [d]
759.9 - 772.4 (2,493 - 2,534)	12.5 (41)	DA	None	**Flow Breccia:** Brownish gray (5YR 4/1) and olive gray (5Y 4/1); strongly silicic; flow banded; rare feldspar phenocrysts; minor biotite; partially altered sphene is present.	Tpb
772.4 - 774.8 (2,534 - 2,542)	2.4 (8)	DA	PS, MP, XRD, XRF, Fe^{2+}/Fe^{3+}	**Vitrophyric Lava:** Black (N1) and brownish black (5YR 2/1); vitric; rare feldspar phenocrysts; no biotite observed; sphene is present.	
774.8 - 780.6 (2,542 - 2,561)	5.8 (19)	DA	None	**Lava:** Pale red (10R 6/2) and pale reddish brown (10R 5/4); quartzo-feldspathic; honey-comb texture; rare feldspar phenocrysts; minor biotite; altered sphene is present; fragments with slickensided surfaces are present. Quartzo-feldspathic alteration, honeycomb texture, and presence of slickensides suggest mild hydrothermal activity along a fault or fault zone.	
780.6 - 788.5 (2,561 - 2,587)	7.9 (26)	DA	None	**Pumiceous Lava:** Grayish orange (10YR 7/4) and light brown (5YR 6/4) mostly zeolitic, partially silicic; rare feldspar phenocrysts; rare biotite; altered sphene is present.	
788.5 - 821.7 (2,587 - 2,696)	33.2 (109)	DA, SC	None	**Bedded Tuff:** Grayish orange pink (5YR 7/2) and grayish yellow (5Y 8/4); zeolitic; minor to common very-pale-orange (10YR 8/2) and moderate-yellow (5Y 7/6) pumice; minor feldspar phenocrysts; minor biotite; rare to minor dark-reddish-brown (10R 3/4) and very-dusky-red (10R 2/2) lithic fragments; altered sphene is present.	
821.7 - 848.9 (2,696 - 2,785)	27.1 (89)	DA	PS, MP, XRD, XRF, Fe^{2+}/Fe^{3+}	**Partially Welded Ash-Flow Tuff:** Moderate brown (5YR 3/4) to 835.2 m (2,740 ft), becoming grayish brown (5YR 3/2) below; devitrified; rare moderate brown (5YR 3/4) pumice; minor partially altered feldspar phenocrysts; rare mafic minerals of partially altered biotite and pseudomorphs after clinopyroxene; trace of lithic fragments; pseudomorphs after sphene are present.	Tpcm

Depth Interval meters (feet)	Thickness meters (feet)	Sample Type [a]	Laboratory Analyses [b]	Lithologic Description [c]	Stratigraphic Unit [d]
848.9 - 894.9 (2,785 - 2,936)	46.0 (151)	DA, SC	PS, MP, XRD, XRF, Fe^{2+}/Fe^{3+}	**Moderately Welded Ash-Flow Tuff:** Moderate brown (5YR 4/4) to 871.7 m (2,860 ft), becoming mostly grayish brown (5YR 3/2) and lesser moderate brown (5YR 4/4) below; devitrified to 871.7 m (2,860 ft), becoming mostly silicic below; spherulitic; no pumice observed; common felsic phenocrysts of feldspar and much less quartz; common mafic minerals of biotite and lesser pseudomorphs after clinopyroxene; rare lithic fragments.	Tpcm
894.9 - 974.1 (2,936 - 3,196)	79.2 (260)	DA, SC	PS, MP, XRD, XRF, Fe^{2+}/Fe^{3+}	**Bedded Tuff:** Light brown (5YR 5/6) to 932.7 m (3,060 ft), becoming grayish orange (10YR 7/4) below; zeolitic; common moderate yellow (5Y 7/6) pumice to 932.7 m (3,060 ft), becoming dusky yellow (5Y 6/4) below; minor to common felsic phenocrysts of quartz and feldspar; minor to common biotite; rare to common lithic fragments.	Thr
974.1 - 998.2 (3,196 - 3,275)	24.1 (79)	DA, SC	PS, MP, XRD, XRF, Fe^{2+}/Fe^{3+}	**Nonwelded Tuff:** Yellowish gray (5Y 8/1); zeolitic; common yellowish-gray (5Y 7/2) pumice; common felsic phenocrysts of quartz and feldspar; minor biotite; rare lithic fragments.	
998.2 - 1,030.5 (3,275 - 3,381)	32.3 (106)	DA, SC	PS, MP, XRD, XRF, Fe^{2+}/Fe^{3+}	**Bedded Tuff:** Yellowish gray (5Y 7/2), pale yellowish brown (10YR 6/2), and grayish yellow (5Y 8/4); zeolitic, partially silicic below 1,027.2 m (3,370 ft); common moderate-greenish-yellow (10Y 7/4) and grayish-green (5G 5/2) pumice; minor to common felsic phenocrysts of feldspar and quartz; rare to minor biotite; rare lithic fragments.	
1,030.5 - 1,035.7 (3,381 - 3,398)	5.2 (17)	DA, SC	None	**Partially to Moderately Welded Ash-Flow Tuff:** Moderate reddish brown (10R 4/6) and moderate brown (5YR 3/4); devitrified; minor grayish-yellow (5Y 8/4) pumice; rare feldspar phenocrysts; rare biotite; rare lithic fragments.	Tcp
1,035.7 - 1,061.3 (3,398 - 3,482)	25.6 (84)	DA	PS, MP, XRD, XRF, Fe^{2+}/Fe^{3+}	**Vitrophyric Ash-Flow Tuff:** Black (N1); vitric; weakly perlitic; rare feldspar phenocrysts; trace of biotite.	

Depth Interval meters (feet)	Thickness meters (feet)	Sample Type [a]	Laboratory Analyses [b]	Lithologic Description [c]	Stratigraphic Unit [d]
1,061.3 - 1,073.5 (3,482 - 3,522)	12.2 (40)	DA	None	**Moderately Welded Ash-Flow Tuff:** Dusky yellowish brown (10YR2/2) and grayish brown (5YR 3/2); devitrified; common pale-greenish-yellow (10Y 8/2) pumice; rare felsic phenocrysts of feldspar and quartz; rare biotite; rare lithic fragments.	Tcp
1,073.5 - 1,097.3 (3,522 - 3,600)	23.8 (78)	DA, SC	None	**Nonwelded to Partially Welded Ash-Flow Tuff:** Grayish red (10R 4/2) and pale brown (5YR 5/2); devitrified; common pale-greenish-yellow (10Y 8/2) and grayish-yellow-green (5GY 7/2) pumice; rare felsic phenocrysts of feldspar and quartz; rare biotite; rare lithic fragments.	
1,097.3 - 1,118.6 (3,600 - 3,670)	21.3 (70)	DA, SC	PS, MP, XRD, XRF, Fe^{2+}/Fe^{3+}	**Bedded Tuff:** Mostly pale yellowish green (10GY 7/2), lesser pale reddish brown (10R 5/4); quartzo-feldspathic; minor to common grayish-yellow-green (5GY 7/2) to moderate-yellowish-green (10GY 6/4) pumice; rare felsic phenocrysts of feldspar and quartz; rare biotite; rare lithic fragments.	Tcbs
1,118.6 - 1,143.0 (3,670 - 3,750)	24.4 (80)	DA, SC	PS, MP, XRD, XRF, Fe^{2+}/Fe^{3+}	**Bedded Tuff:** Grayish orange (10YR 7/4); quartzo-feldspathic; minor yellowish-gray (5Y 7/2) pumice; rare felsic phenocrysts of feldspar and quartz; rare biotite; rare grayish-red (5R 4/2) lithic fragments of silicic lava containing quartz and biotite.	
1,143.0 - 1,172.9 (3,750 - 3,848)	29.9 (98)	DA	PS, MP, XRD, XRF, Fe^{2+}/Fe^{3+}	**Bedded Tuff:** Grayish yellow (5Y 8/4) and yellowish gray (5Y 7/2); quartzo-feldspathic; minor moderate-greenish-yellow (10Y 7/4) pumice; rare felsic phenocrysts of feldspar and quartz; rare biotite; rare grayish-red (5R 4/2) lithic fragments of silicic lava containing quartz and biotite.	

Depth Interval meters (feet)	Thickness meters (feet)	Sample Type [a]	Laboratory Analyses [b]	Lithologic Description [c]	Stratigraphic Unit [d]
1,172.9 - 1,212.2 (3,848 - 3,977)	39.3 (129)	DA, SC	None	**Bedded Tuff:** Very pale orange (10YR 8/2), becoming light greenish gray (5GY 8/1) lower; quartzo-feldspathic; minor to common very pale orange (10YR 8/2) and pale yellowish green (10GY 7/2) pumice; minor to common felsic phenocrysts of feldspar and quartz; minor biotite; minor to common grayish-red (10R 4/2) and grayish-purple (5P 4/2) lithic fragments of silicic lava containing abundant felsic phenocrysts of quartz and feldspar, and minor biotite.	Tcbs
1,212.2 - 1,301.5 (3,977 - 4,270)	89.3 (293)	DA, SC	PS, MP, XRD, XRF, Fe^{2+}/Fe^{3+}	**Bedded Tuff:** Mostly pale yellowish green (10GY 7/2), lesser pale red (5R 6/2); quartzo-feldspathic; common pale-green (5G 7/2) pumice; minor to common felsic phenocrysts of feldspar and quartz; minor biotite; rare lithic fragments.	
1,301.5 - 1,333.5 (4,270 - 4,375)	32.0 (105)	DA, SC	PS, MP, XRD, XRF, Fe^{2+}/Fe^{3+}	**Pumiceous Lava:** Pale yellowish green (10GY 7/2), becoming moderate-yellowish-brown (10YR 5/4) at base; quartzo-feldspathic, mostly silicic at base; rare feldspar phenocrysts; no mafic minerals; no lithic fragments.	Tqu
1,333.5 - 1,405.7 (4,375 - 4,612)	72.2 (237)	DA, SC	None	**Lava and Flow Breccia:** Pale red (5R 4/2), dark reddish brown (10R 3/4), and pale yellowish green (10GY 7/2); quartzo-feldspathic; remnant perlitic and pumiceous texture, flow banded, strongly spherulitic; rare felsic phenocrysts of feldspar and much less quartz; trace of biotite and pseudomorphs of biotite.	
1,405.7 - 1,420.4 (4,612 - 4,660)	14.6 (48)	DA	PS, MP, XRD, XRF, Fe^{2+}/Fe^{3+}	**Vitrophyric Lava:** Black (N1) and lesser brownish black (5YR 2/1); mostly vitric, partially quartzo-feldspathic; weakly perlitic; rare feldspar phenocrysts; no mafic minerals observed.	
1,420.4 - 1,456.6 (4,660 - 4,779)	36.3 (119)	DA, SC	None	**Pumiceous Lava:** Mottled pale yellowish green (10GY 7/2) and pale red (10R 6/2); quartzo-feldspathic; rare felsic phenocrysts of feldspar and lesser quartz; rare pseudomorphs after biotite.	

Depth Interval meters (feet)	**Thickness** meters (feet)	**Sample Type** [a]	**Laboratory Analyses** [b]	**Lithologic Description** [c]	**Stratigraphic Unit** [d]
1,456.6 - 1,469.4 (4,779 - 4,821)	12.8 (42)	DA	None	**Bedded Tuff:** Pale reddish brown (10R 5/4), dark reddish brown (10R 3/4), pale brown (5YR 5/2), and yellowish gray (5Y 7/2); quartzo-feldspathic; rare to minor moderate-yellow (5Y 7/6) pumice; rare felsic phenocrysts of feldspar and lesser quartz; rare biotite; rare lithic fragments.	Tqu
1,469.4 - 1,524.0 (4,821 - 5,000)	54.6 (179)	DA, SC	PS, MP, XRD, XRF, Fe^{2+}/Fe^{3+}	**Flow Breccia:** Mottled dusky green (5G 3/2), grayish green (5G 5/2), grayish red (5R 4/2), and grayish yellow (5Y 8/4); quartzo-feldspathic, minor argillic and calcic; very pumiceous above 1,478.6 m (4,851 ft); minor felsic phenocrysts of feldspar and much less quartz; very abundant biotite.	Tqbl

a **DA** = drill cuttings that represent lithologic character of interval; **DB1** = drill cuttings enriched in hard components; **DB2** = drill cuttings from interval different than that drilled; **SC** = sidewall core.

b Notations refer to completed, partially completed, and pending analyses. See Table 3-2 of this report for additional information. **PS** = polished thin section; **MP** = electron microprobe; **XRD** = X-ray diffraction; **XRF** = X-ray fluorescence; **Fe^{2+}/Fe^{3+}** = wet chemical analysis for iron.

c Descriptions are based mainly on visual examination of lithologic samples using a 10x- to 40x-zoom binocular microscope and geophysical logs. Additional data from laboratory analyses have been incorporated into the descriptions. Colors describe wet sample color.

Abundances for felsic phenocrysts, pumice fragments, and lithic fragments: **trace** = only one or two individuals observed; **rare** = $\leq$ 1%; **minor** = 5%; **common** = 10%; **abundant** = 15%; **very abundant** = $\geq$ 20%.

Abundances for mafic minerals: **trace** = only one or two individuals observed; **rare** = $\leq$ 0.05%; **minor** = 0.2%; **common** = 0.5%; **abundant** = 1%; **very abundant** = $\geq$ 2%.

d **Ttt** = Trail Ridge Tuff; **Ttp/Ttr** = Pahute Mesa and Rocket Wash Tuffs, undivided; **Tmap** = mafic-poor Ammonia Tanks Tuff; **Tmat** = rhyolite of Tannenbaum Hill; **Tmrp** = mafic-poor Rainier Mesa Tuff; **Tmrf** = rhyolite of Fluorspar Canyon; **Tpb** = rhyolite of Benham; **Tpcm** = Pahute Mesa lobe of Tiva Canyon Tuff; **Thr** = mafic-rich Calico Hills Formation; **Tcp** = Prow Pass Tuff; **Tcbs** = Stockade Wash lobe of Bullfrog Tuff; **Tqu** = tuff of Schooner; **Tqbl** = lower biotite-bearing rhyolite of Quartz Mountain.

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Appendix D
Geophysical Logs Run in Well ER-EC-1

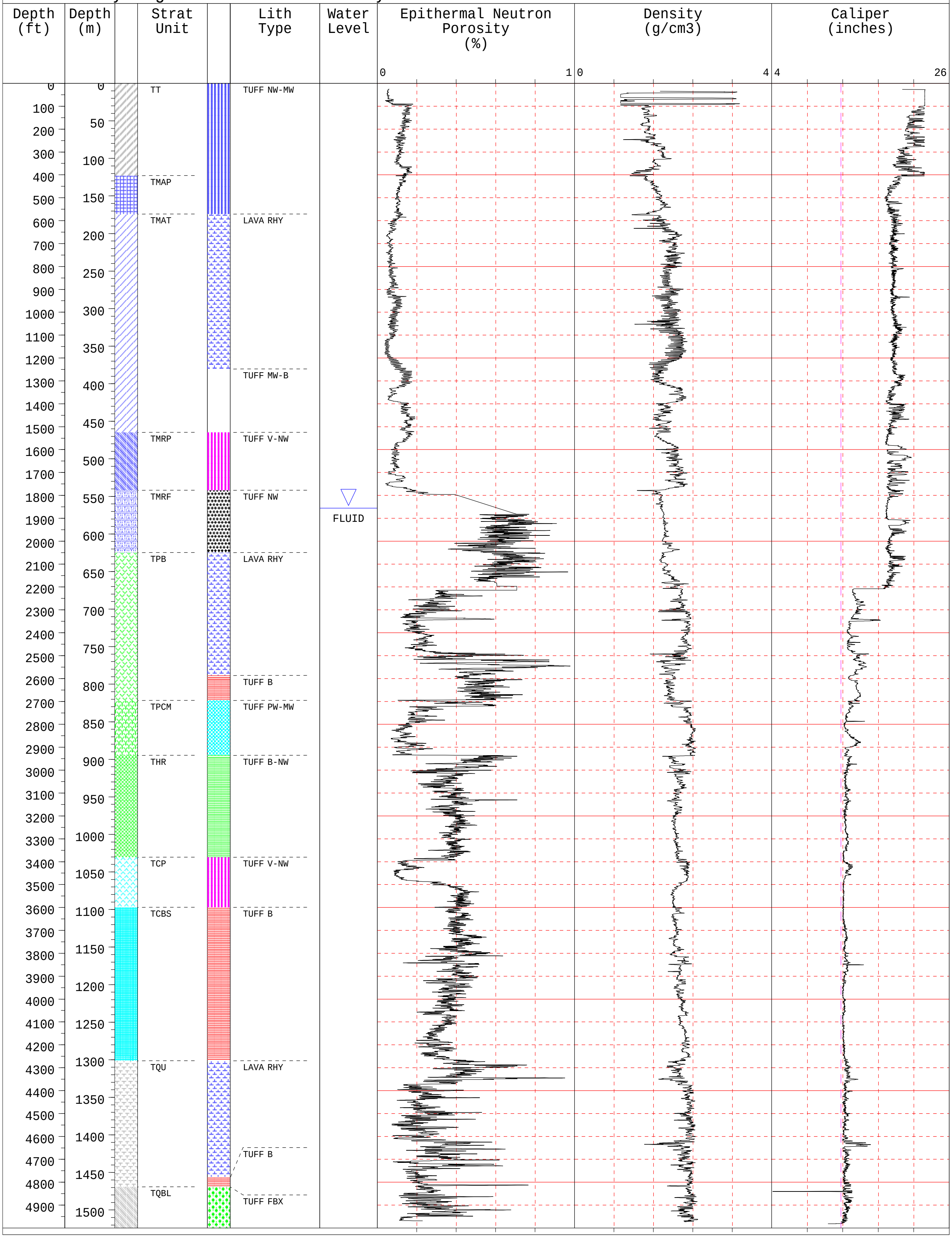
Appendix D contains unprocessed data presentations of selected geophysical logs run in Well ER-EC-1. Table D-1 summarizes the logs presented. See Table 3-3 for more information.

Table D-1
Well ER-EC-1 Geophysical Logs Presented

Log Type	Run Number	Date	Log Interval meters	feet
Epithermal Neutron	ENP-1 ENP-2	04/11/1999 04/21/1999	23.3 - 662.0 666.9 - 1,512.7	76.4 - 2,172 2,188 - 4,963
Density	CDL-1 CDL-2	04/11/1999 04/21/1999	23.3 - 662.0 666.9 - 1,512.7	76.4 - 2,172 2,188 - 4,963
Array Induction and Dual Laterolog (resistivity)	IND-1 DLL-1	04/11/1999 04/21/1999	23.3. - 669.0 667.5 - 1,513.0	76.4 - 2,195 2,190 - 4,964
Spontaneous Potential	SP	04/21/1999	667.5 - 1,513.0	2,190 - 4,964
Gamma Ray	SGR-1 GR-2	04/11/1999 04/21/1999	23.3 - 671.2 666.9 - 1,519.1	76.4 - 2,172 2,188 - 4,963
Digital Array Sonic (delta T and sonic porosity)	AC-1	04/21/1999	667.5 - 1,503.9	2,190 - 4,934
Spectral Gamma Ray (potassium, thorium, uranium)	SGR-1 SGR-2	04/11/1999 04/20/1999	23.3 - 659.0 655.9 - 1,514.2	76.4 - 2,162 2,188 - 4,984
Thermal Flow	1	04/22/1999	729.1 - 1,508.8	2,392 - 4,950
Chemistry (temperature, pH, electrical conductivity)	1	04/22/1999	566.6 - 1,517.6	1,859 - 4,979

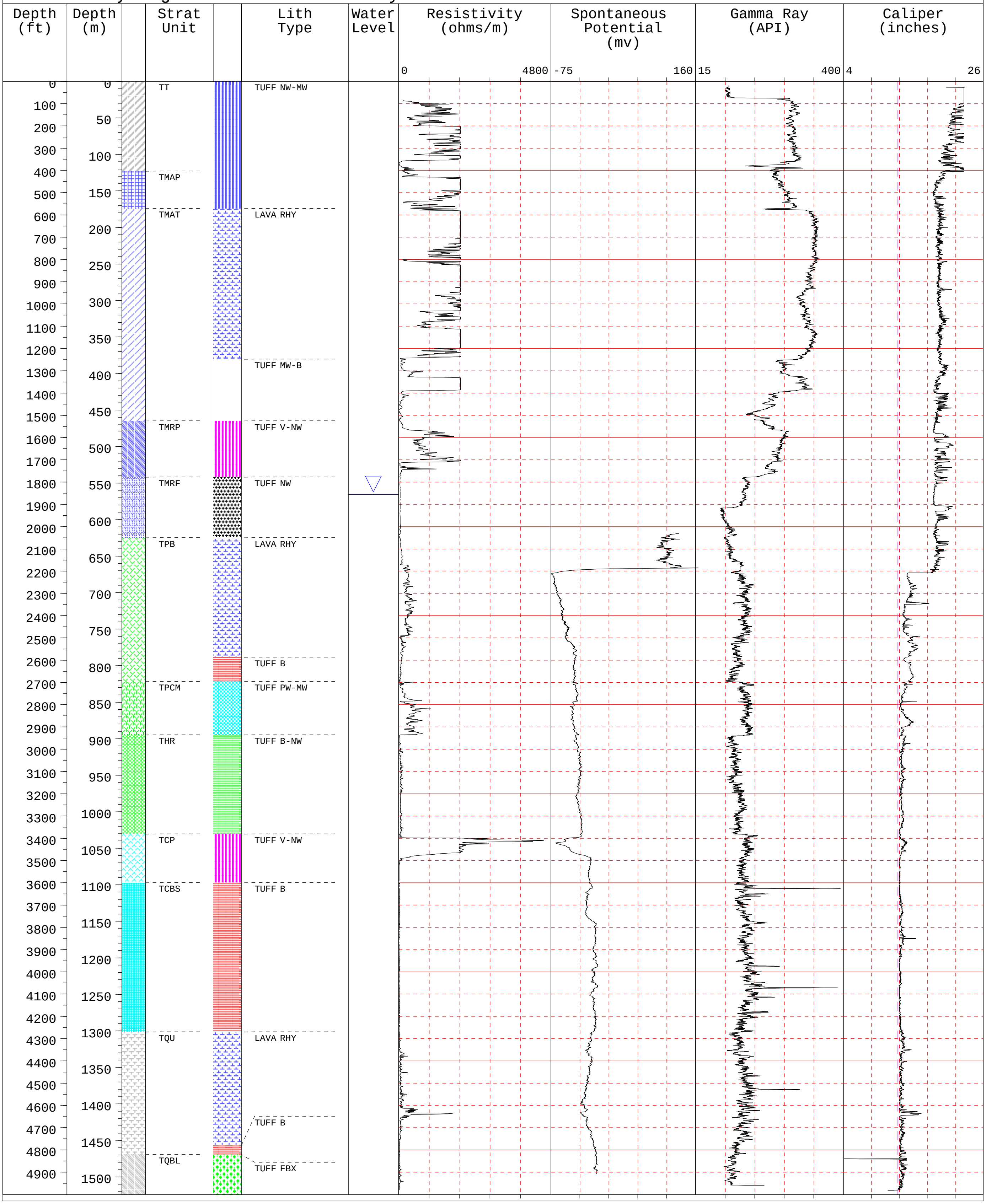
Well Name: ER-EC-1	Western Pahute Mesa - Oasis Valley Drilling Program		Northing: 4117856.7 m
Date: 7/29/99	Start Date: 4/4/99	Stop Date: 4/27/99	Easting: 541649.5 m
Environmental Contractor: UGTA/IT		Proj No: 776706.02.08.02.02	Surface Elevation: 6025.6 ft
Drilling Contractor: United	Drilling Method: Air Foam	Geol: J. Wurtz	Depth: 5000.00 ft.

Preliminary Log for Information Only



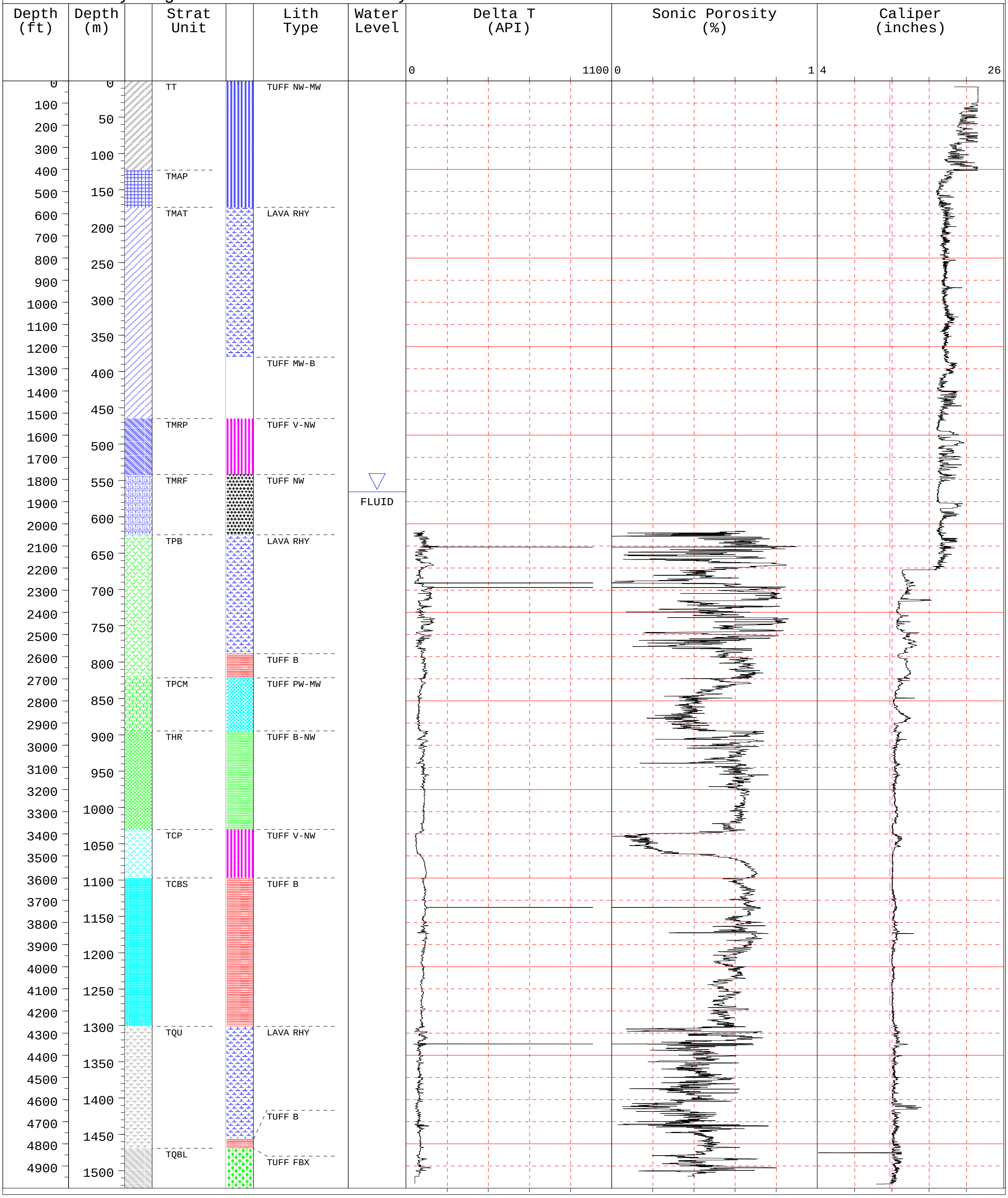
Well Name: ER-EC-1	Western Pahute Mesa - Oasis Valley Drilling Program		Northing: 4117856.7 m
Date: 7/29/99	Start Date: 4/4/99	Stop Date: 4/27/99	Easting: 541649.5 m
Environmental Contractor: UGTA/IT		Proj No: 776706.02.08.02.02	Surface Elevation: 6025.6 ft
Drilling Contractor: United	Drilling Method: Air Foam	Geol: J. Wurtz	Depth: 5000.00 ft.

Preliminary Log for Information Only



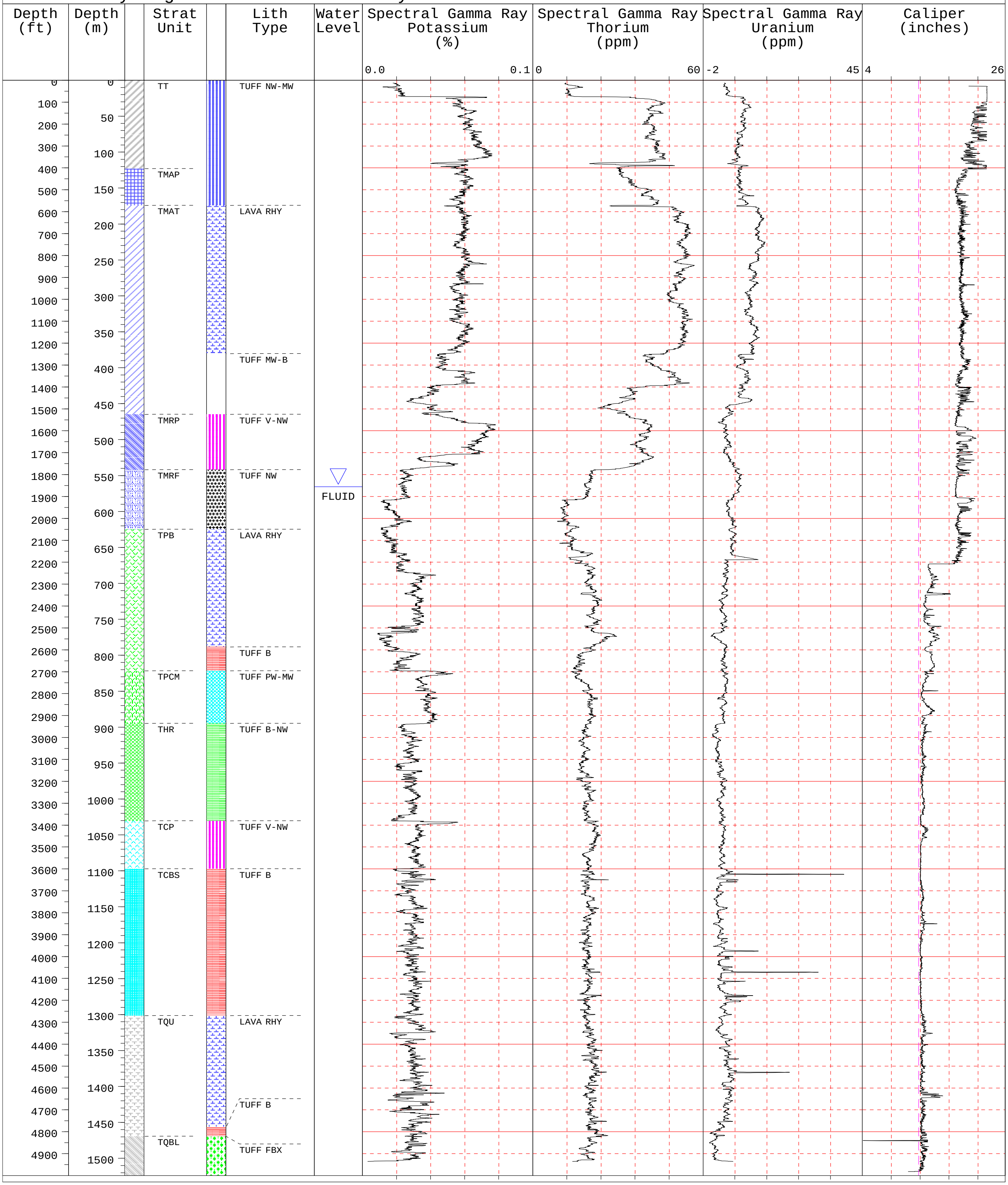
Well Name: ER-EC-1	Western Pahute Mesa - Oasis Valley Drilling Program		Northing: 4117856.7 m
Date: 7/29/99	Start Date: 4/4/99	Stop Date: 4/27/99	Easting: 541649.5 m
Environmental Contractor: UGTA/IT		Proj No: 776706.02.08.02.02	Surface Elevation: 6025.6 ft
Drilling Contractor: United	Drilling Method: Air Foam	Geol: J. Wurtz	Depth: 5000.00 ft.

Preliminary Log for Information Only



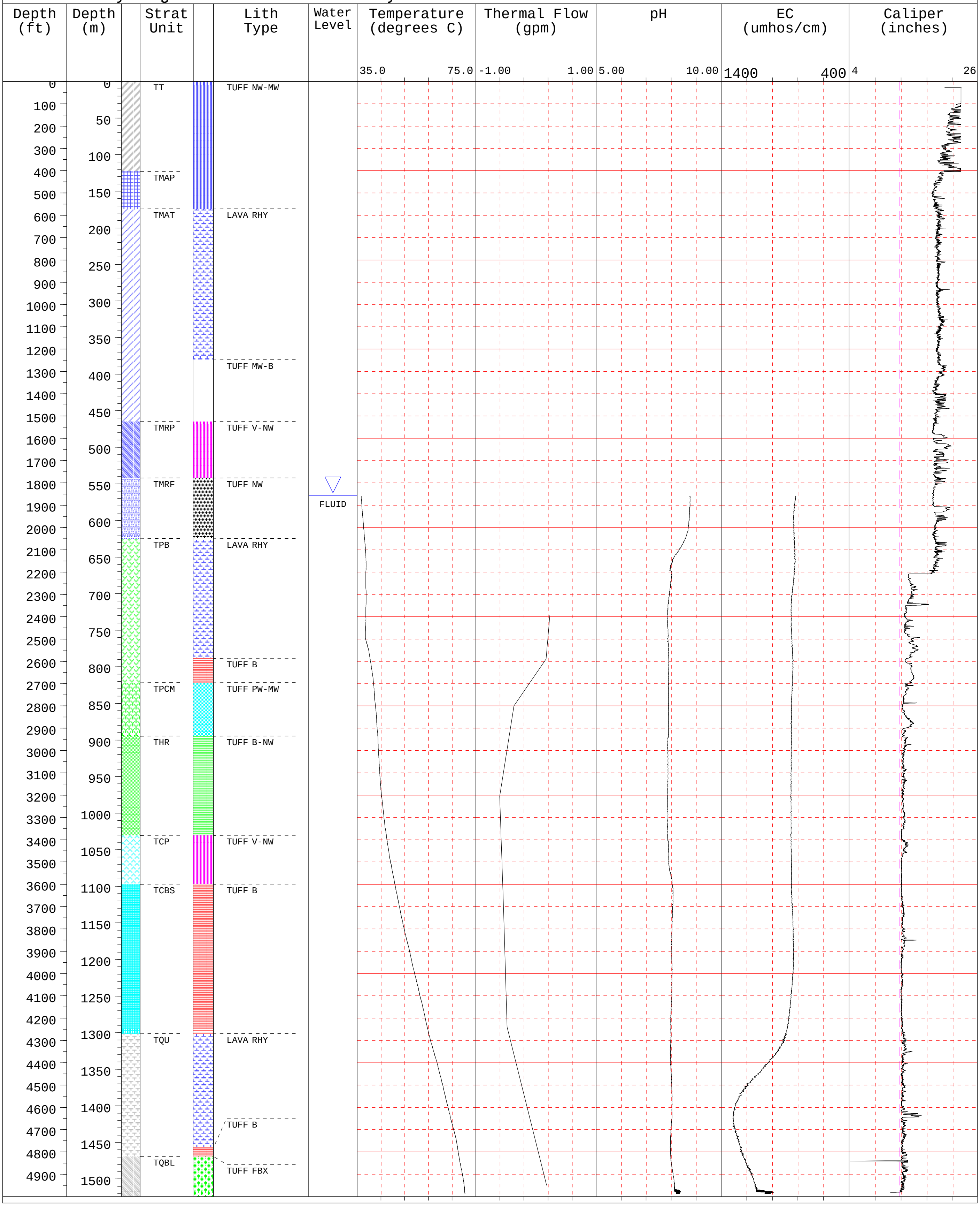
Well Name: ER-EC-1	Western Pahute Mesa - Oasis Valley Drilling Program	Northing: 4117856.7 m
Date: 7/29/99	Start Date: 4/4/99 / Stop Date: 4/27/99	Easting: 541649.5 m
Environmental Contractor: UGTA/IT	Proj No: 776706.02.08.02.02	Surface Elevation: 6025.6 ft
Drilling Contractor: United	Drilling Method: Air Foam / Geol: J. Wurtz	Depth: 5000.00 ft.

Preliminary Log for Information Only



Well Name: ER-EC-1	Western Pahute Mesa - Oasis Valley Drilling Program		Northing: 4117856.7 m
Date: 7/29/99	Start Date: 4/4/99	Stop Date: 4/27/99	Easting: 541649.5 m
Environmental Contractor: UGTA/IT		Proj No: 776706.02.08.02.02	Surface Elevation: 6025.6 ft
Drilling Contr.: United	Drilling Meth: Air Foam	Geol: J. Wurtz	Depth: 5000.00 ft.

Preliminary Log for Information Only



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