Nevada
Environmental
Restoration
Project

DOE/NV-407
UC-700

Completion Report for Well ER-30-1

December 1995

Environmental Restoration
Division

U.S. Department of Energy
Nevada Operations Office

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COMPLETION REPORT FOR WELL ER-30-1

Prepared for

DOE Nevada Operations Office
Las Vegas, Nevada

Prepared by

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December 1995

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COMPLETION REPORT FOR WELL ER-30-1

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List of Acronyms and Abbreviations

AWS	Atlas Wireline Services
cm	centimeter
ft	foot
DOE	U.S. Department of Energy
DRI	Desert Research Institute
gal	gallon
gpm	gallon per minute
in.	inch
IT	IT Corporation
km	kilometer
ℓ	liter
ℓpm	liter per minute
m	meter
m^3/min	cubic meter per minute
mi	mile
NTS	Nevada Test Site
od	outside diameter
REECo	Reynolds Electrical & Engineering Co., Inc.
RSN	Raytheon Services Nevada
TD	total depth
TDR	time domain reflectometry
TFM	thermal flow meter
UGTA	Underground Test Area
USGS	U.S. Geological Survey

1.0 Introduction

1.1 Project Description

Well ER-30-1 was drilled for the U.S. Department of Energy (DOE), Nevada Operations Office, in support of the Nevada Environmental Restoration Project at the Nevada Test Site (NTS). IT Corporation (IT) was the principal environmental contractor for the project. The roles and responsibilities of IT and other contractors involved in the project are described in the Raytheon Services Nevada (RSN) Drilling and Completion Programs (RSN, 1994a,b) and the *Underground Test Area Operable Unit Project Management Plan* (DOE, 1994a). The Well ER-30-1 investigation is part of the DOE's Underground Test Area (UGTA) Project at the NTS, the goals of which include collecting geological, geophysical, hydrological, and water-chemistry data from new and existing wells to define groundwater migration pathways, rates of migration, and groundwater quality at the NTS. The well will become part of the UGTA monitoring well network.

Well ER-30-1 was drilled as an exploratory well in the north central portion of Area 30, in upper Fortymile Canyon (Figure 1-1). The nearest announced underground nuclear test was conducted approximately 7.3 kilometers (km) (4.5 miles [mi]) southwest of the site, at a shallow depth and well above the water table. No radionuclides were expected in Well ER-30-1, so the primary goal of drilling was to obtain geologic and hydrologic data for this relatively unexplored area near the western boundary of the NTS. This site is in the eastern part of the "moat" of the Timber Mountain caldera, an area of relatively thick, but not very extensive, saturated Tertiary gravels and volcanic rocks. The nearest drill holes from which geologic data are available are U-18j#1 and UE-18t located approximately 6.1 and 8.9 km (3.8 and 5.5 mi) to the north, respectively (Figure 1-2).

The Nevada State Planar Coordinates of the site are N837,451.0, E602,275.6 feet (ft). The ground surface elevation at the wellhead is 1.416.5 meters (m) (4,647.4 ft) above sea level. Additional site summary and survey information is given on Table 1-1.

This report presents construction data and summarizes scientific data gathered during the drilling and well-installation phases of the investigation. Most of the information in this report is preliminary and unprocessed, compiled to summarize the drilling history, geophysical data, and well-installation design. However, the lithologic log is provided in final form. Information on

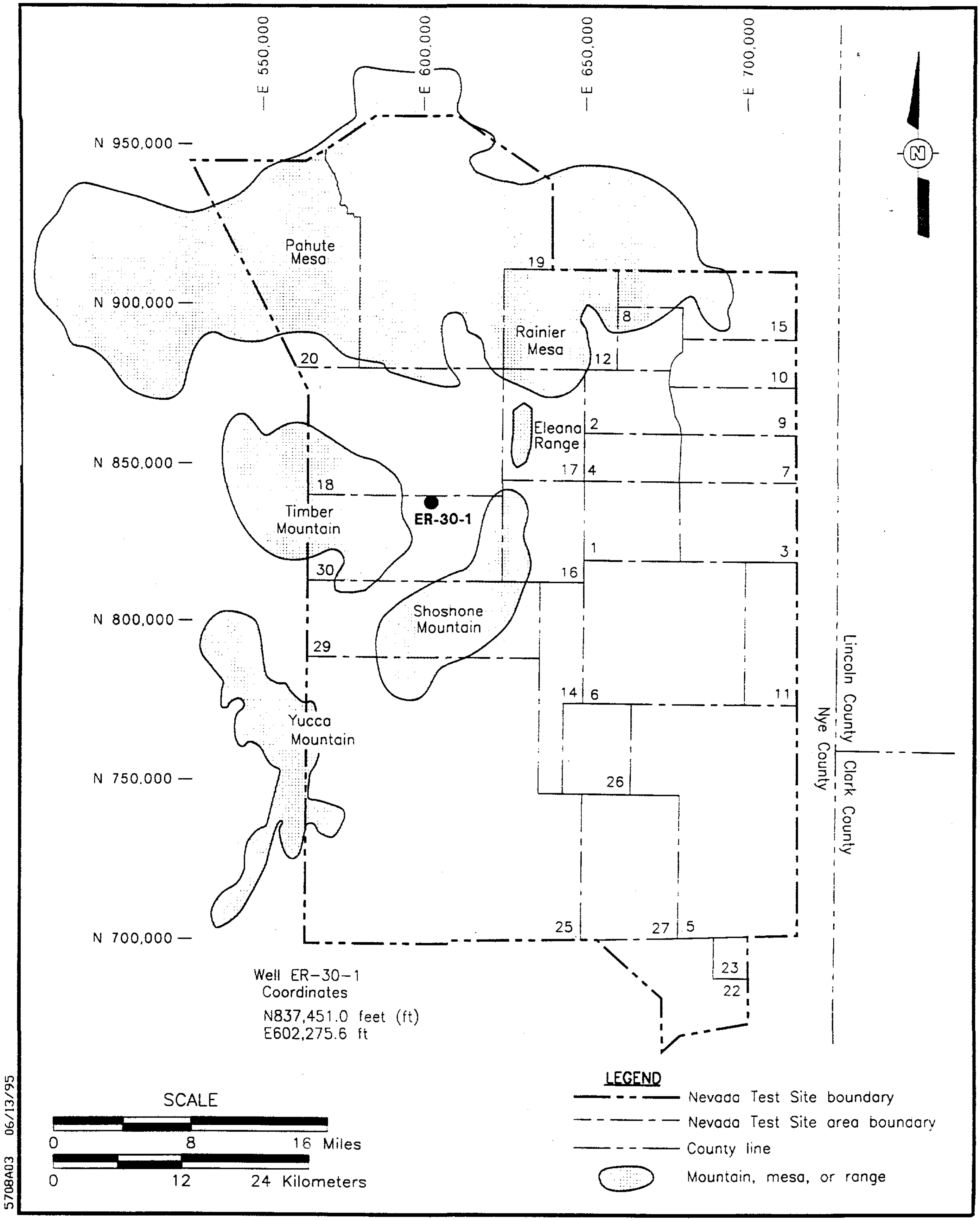

Figure 1-1
Location of Well ER-30-1

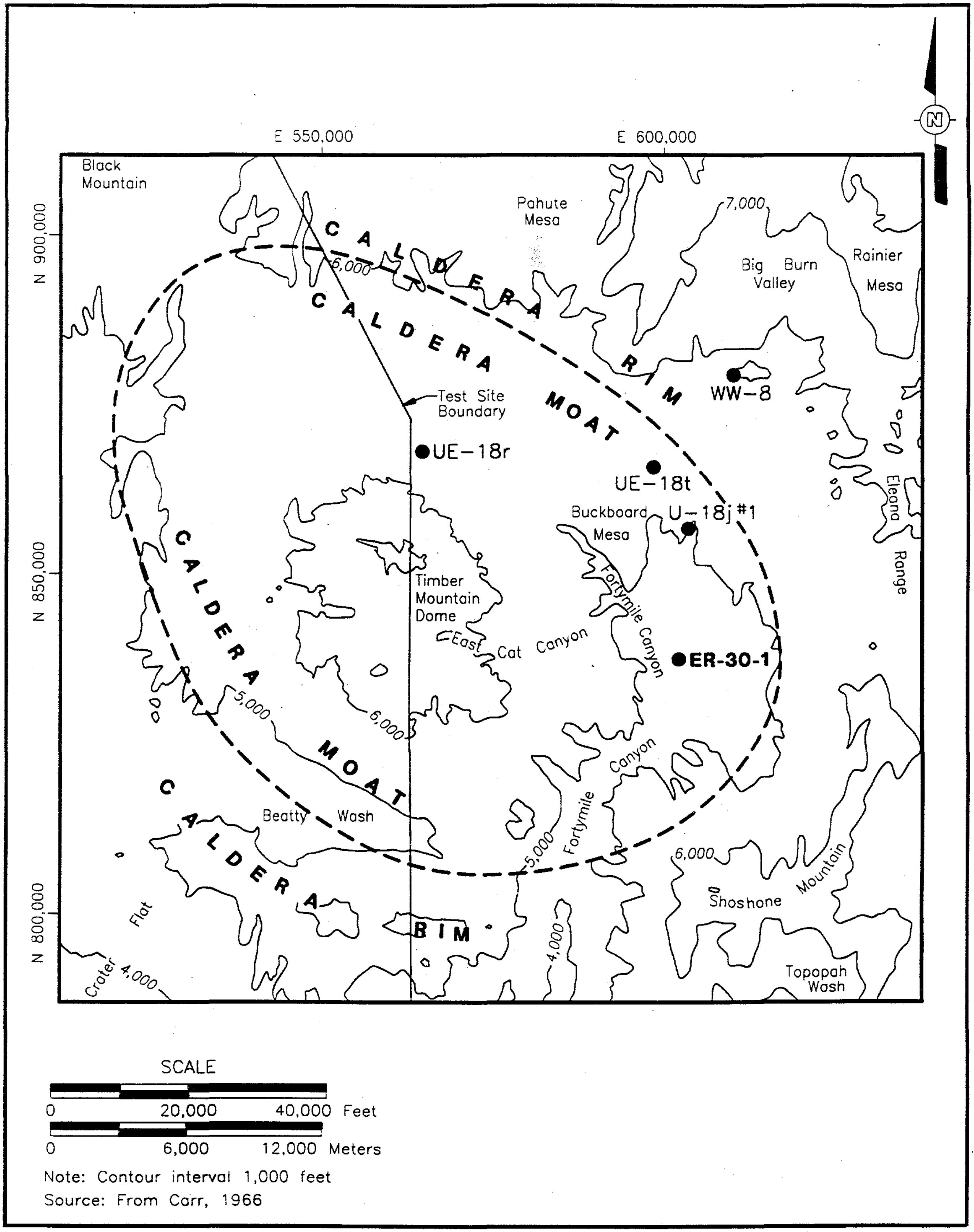

Figure 1-2
Map Showing Location of Drill Holes in the Vicinity of Well ER-30-1

Table 1-1
Well ER-30-1 Site Summary

Hole Designation	Well ER-30-1
Site Coordinates[a]	Central Nevada State Planar: N837,451.0, E602,275.6 feet (ft) Universal Transverse Mercator (Zone 11): N4,100,463.0, E560,804.5 meters (m)
Surface Elevation[b]	1,416.5 m (4,647.4 ft)
Drilled Depth	434.6 m (1,426 ft)
Fluid-Level Depth (open borehole)	137.5 m (451 ft)
Fluid-Level Elevation	1,279 m (4,196 ft)

[a] 1927 North American Datum. Measurement made by RSN Survey.
[b] 1929 North American Vertical Datum. Measurement made by RSN Survey.

well development, water levels, aquifer testing, and groundwater analytical sampling will be presented in a future hydrologic data report. Additional information on the results of geologic and geophysical investigations will be presented in one or more analysis and interpretation reports.

1.2 Objectives

The primary purpose of Well ER-30-1 was to provide water-level and stratigraphic data to supplement information acquired at other locations within the western NTS. Individual objectives, as discussed in the Well ER-30-1 Drilling/Completion Criteria Document (IT, 1994) include the following:

- Obtain water-level data to refine the understanding of the direction of groundwater flow in the western part of the NTS
- Obtain stratigraphic information regarding caldera-filling deposits in the eastern Timber Mountain caldera moat, as these deposits may influence the groundwater flow regime
- Obtain groundwater samples for determination of local groundwater chemistry
- Detect, if present, perched water (separated from underlying saturated rocks by intervening low-permeability rocks) in the rocks penetrated by the well
- Provide a long-term groundwater monitoring point for this area of the NTS.

1.3 Project Summary

Well ER-30-1 was drilled with conventional rotary drilling techniques using a direct circulation system to a total depth (TD) of 434.6 m (1,426.0 ft) between February 7, 1994, and March 21, 1994. Following auger-drilling of a 1.22-m (48-inch [in.]) hole for the surface casing, a 44.5-centimeter (cm) (17½-in.) hole was drilled to 282.2 m (926 ft). Water production was noted at the depth of 140 m (459 ft) and continued at a high rate for the remainder of drilling (see Section 5.0). Borehole sloughing problems required cementing and redrilling, and after the second cementing procedure, a 31.1-cm (12¼-in.) bit was used to drill through the cement and rock from 246.9 to 434.6 m (810 to 1,426 ft), at which point circulation was lost and the drilling assembly became stuck on March 16, 1995. The assembly was freed the next day, but obstructions and fill were encountered and drilled out several times during logging. Thus, after three days of effort, the drilled depth of 434.6 m (1,426 ft) was determined to be acceptable as the TD (though the planned depth had been 609.6 m [2,000 ft]) because it was deemed not cost-effective to continue drilling efforts in the face of severe sloughing problems. The hole was left with 149.7 m (491 ft) of fill, leaving a working depth in the well of 285.0 m (935 ft).

Composite drill cuttings were obtained every three meters from the surface to the TD, and two series of percussion-gun sidewall core samples were taken. Geophysical logs were run periodically during drilling to aid in drilling and construction of the well and after drilling was completed to aid in verification of the geology and the hydrologic characteristics of the units. The hole penetrated Quaternary- and Tertiary-age alluvium and gravel deposits and several Tertiary volcanic units.

Two 2⅞-in. piezometer strings, each with a Moyno® pump stator, positioned above the slotted section, were installed in Well ER-30-1. String #1 (the lowermost piezometer string) was landed off at 239.6 m (786 ft), with a screened interval located between 227.2 and 233.3 m (745 to 765 ft). This piezometer was gravel-packed and the annulus cemented to 191.5 m (628 ft). String #2 (the uppermost piezometer string) was landed off at 191.5 m (628 ft), with a screened interval located between 179.1 and 185.2 m (588 to 608 ft). This piezometer was also gravel-packed, and the annulus was cemented to the surface. Fluid levels were found to be at 138.1 m (452.9 ft) in String #1 and 138.0 m (452.8 ft) in String #2 on June 21, 1994.

Because drilling of Well ER-30-1 was stopped approximately 175 m (574 ft) shallower than the proposed depth of 610 m (2,000 ft), less geologic data than desired were obtained from the hole. However, the relatively high water table in this well allowed for successful completions at shallower depths than originally proposed, and the overall objective of drilling and installing a well to provide hydrologic information of the western part of the NTS has been met.

1.4 Project Manager

Inquiries regarding Well ER-30-1 should be directed to Mr. Steven J. Lawrence, UGTA, Project Manager at:

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Las Vegas, Nevada 89193-8518

2.0 Drilling Summary

2.1 Introduction

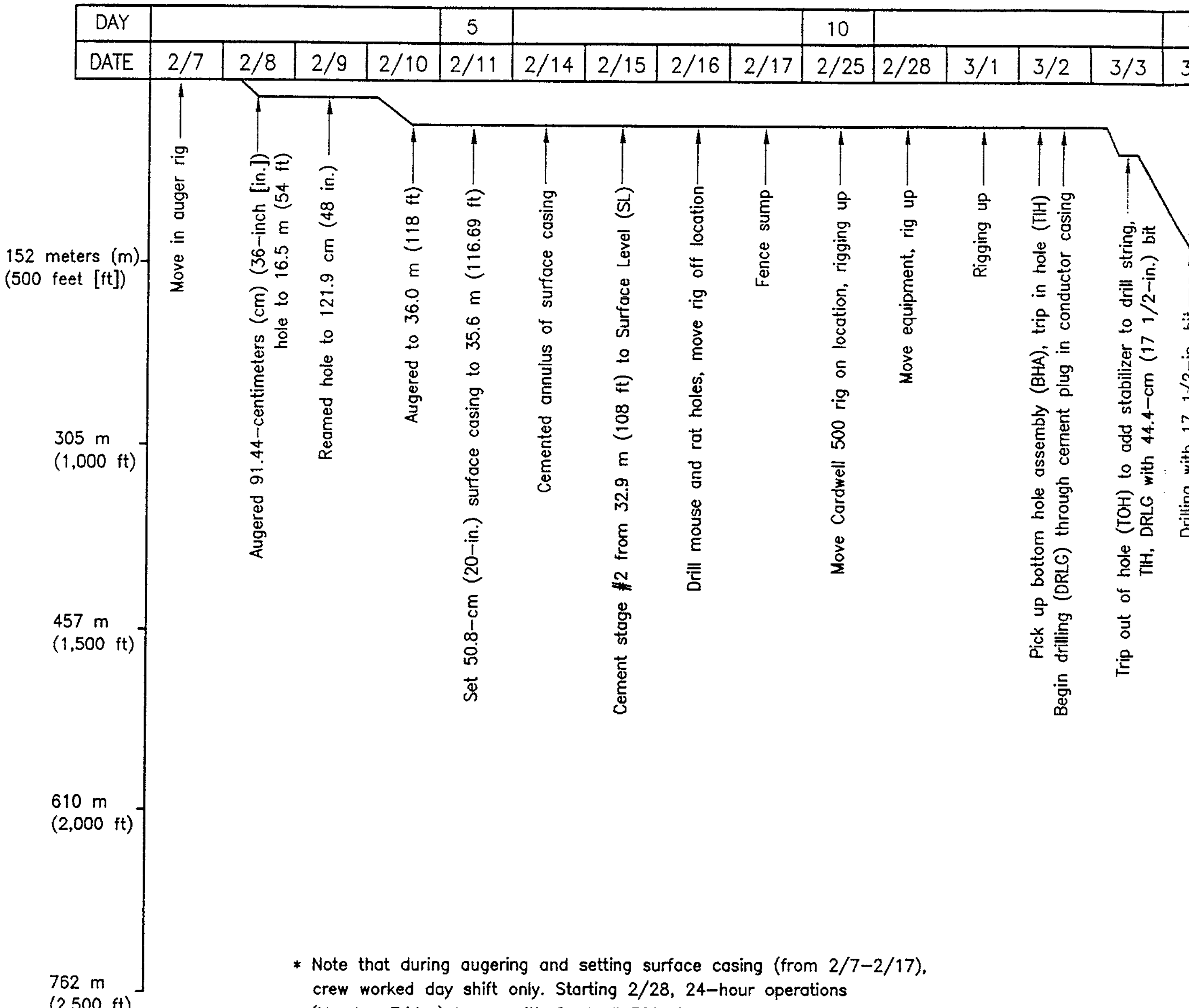
The drilling requirements for Well ER-30-1 were outlined in the RSN Drilling Program (RSN, 1994a), and changes to the RSN program were documented in RSN Records of Verbal Communication (Appendix A-1). This summary was compiled from the RSN daily rig reports, field notes prepared by the IT Field Representative, and from the RSN ER-30-1 Hole History (RSN, 1995), where complete details of drilling activities can be found. Figure 2-1 is a chart of the drilling and completion history for Well ER-30-1. A summary of drilling statistics for Well ER-30-1 is given in Table 2-1.

2.2 Drilling History

Drilling operations at Well ER-30-1 began on February 7, 1994, with the mobilization of a Class VIII auger rig to drill for and set surface casing. A 1.22-m (48-in.) diameter hole was dry-augured by personnel of Reynolds Electrical & Engineering Co., Inc. (REECo) to 36.0 m (118 ft) in five stages starting with a 91-cm (36-in.) bit. A 50.8-cm (20-in.) outside-diameter (od) casing was set to 35.6 m (117 ft) on February 11, 1994, and the annulus was cemented to the ground surface on February 14 and 15, 1994. The next day was spent drilling the mouse and rat holes, and work on the hole was suspended until February 25, 1994.

When operations resumed, an International Petroleum Service/Cardwell 500 drill rig was mobilized to the site, and rotary drilling began on March 2, 1994, using direct circulation with bentonite air-foam drilling fluid (Appendix A-4). During the period from March 2 to March 7, 1994, a 44.5 cm (17½-in.) hole was drilled to 282.2 m (926 ft). Water was encountered during drilling on March 4, 1994, at approximately 140 m (459 ft). Drilling problems due to borehole sloughing below 250 m (820 ft) necessitated cementing off the zone from 246.9 to 281.9 m (810 to 925 ft) on March 8, 1994. Drilling resumed on March 9, 1994, with a 31.1-cm (12¼-in.) bit, and sloughed fill was drilled to the previously attained depth of 282.2 m (926 ft). Unstable, sloughing borehole conditions persisted, requiring the borehole to be cemented in the interval 248.1 to 295.0 m (814 to 968 ft). Drilling continued with the 31.1-cm (12¼-in.) bit on March 11, 1994, following completion of cementing operations.

After drilling to 417.3 m (1,369 ft), drilling activities were shut down to allow trucking of drilling return fluids from the site. Removal of the fluids had become necessary because higher than anticipated groundwater production rates of 1.89 to 2.27 cubic meters per minute (m^3/min)



* Note that during augering and setting surface casing (from 2/7–2/17), crew worked day shift only. Starting 2/28, 24-hour operations (Monday–Friday) began with Cardwell 500 rig.

<u>ER-30-1</u>

Hole spudded	02/07/94
Surface hole completed and cased	02/15/94
Drilling of 0.45-m (17 1/2-in.) hole begins	03/02/94
Reached total drilled depth of 434.6 m (1,426 ft)	03/17/94
Completed well (with fill to depth of 285.0 m [935 ft])	03/25/94

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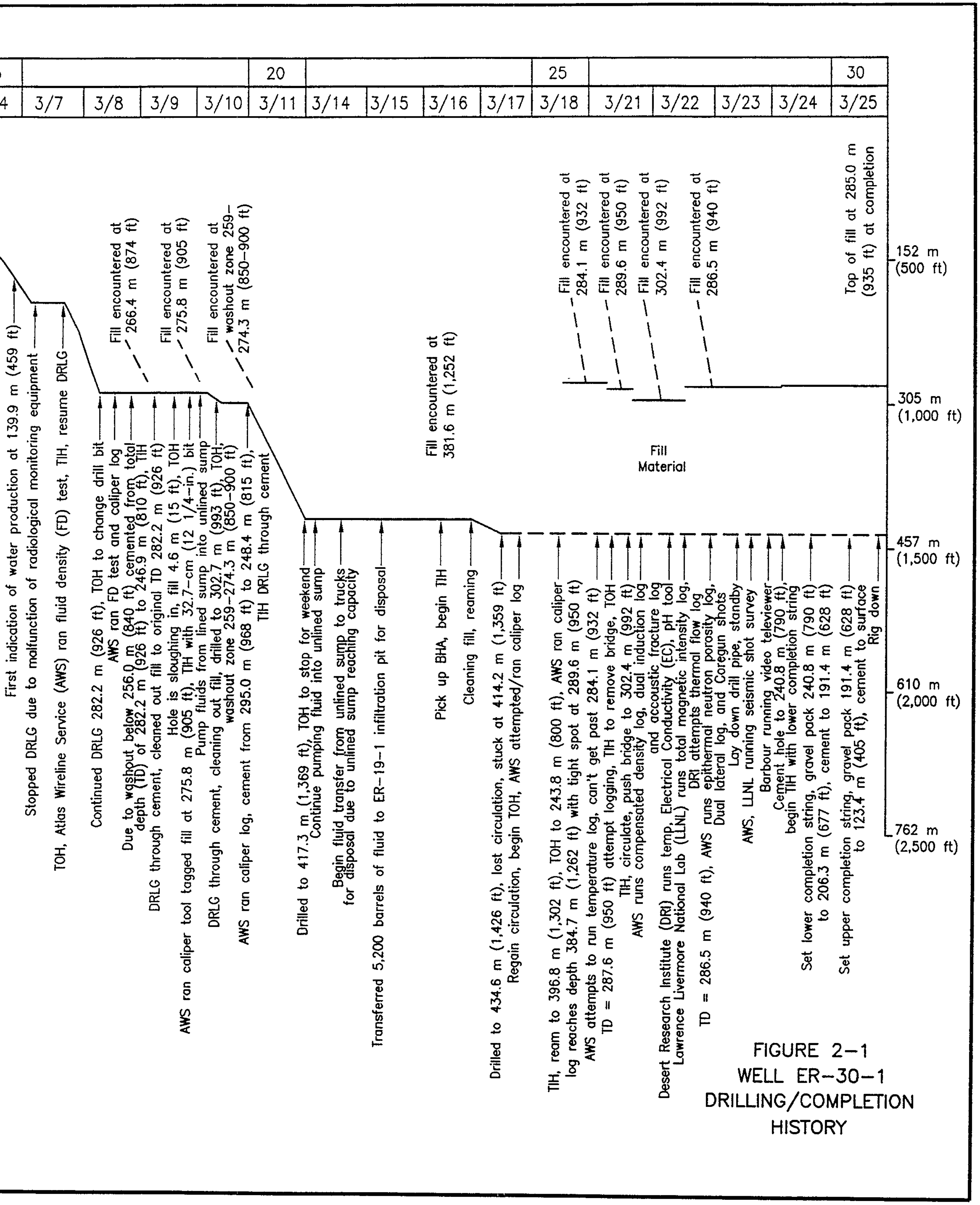

FIGURE 2-1
WELL ER-30-1
DRILLING/COMPLETION
HISTORY

Table 2-1
Abridged Drill Hole Statistics for Well ER-30-1

LOCATION DATA: Coordinates — Central Nevada State Planar: N837,451.0, E602,275.6 feet (ft)
Universal Transverse Mercator: N4,100,454.8, E560,803.4 meters (m)

Ground Elevation 1,416.5 m (4,647.4 ft)

DRILLING DATA:

Spud Date:	2/07/94 (auger rig); 3/02/94 (Cardwell 500)
Total Depth (TD):	434.6 m (1,426 ft)
Date TD Reached:	3/17/94
Date Well Completed:	3/25/94
Original Hole Diameter:	1.22 m (48 inches [in.]) from surface to 36.0 m (118 ft); 44.5 centimeters (cm) (17.5 in.) from 36.0 m (118 ft) to 282.2 m (926 ft); 31.1 cm (12¼ in.) from 282.2 m (926 ft) to 434.6 m (1,426 ft).
Current Hole Diameter: (due to cementing)	1.22 m (48 in.) from surface to 36.0 m (118 ft); 44.45 cm (17½ in.) from 36.0 m (118 ft) to 246.8 m (810 ft); 31.12 cm (12¼ in.) from 246.8 m (810 ft) to 434.6 m (1,426 ft).
Drilling Techniques:	Dry-hole auger from surface to 36.0 m (118 ft). Air-foam rotary drilling from 36.0 m (118 ft) to 282.2 m (926 ft) using a 44.5-cm (17½-in.) tri-cone bit with conventional circulation. Air-foam rotary drilling from 282.2 m (926 ft) to 434.6 m (1,426 ft) using a 31.1-cm (12¼-in.) tri-cone bit with conventional circulation.

CASING DATA: 49.5-cm (20-in.) casing from surface to 35.7 m (117 ft).
No intermediate casing set in hole.

WELL COMPLETION DATA:
Two piezometer strings consisting of 7.3-cm (2⅞-in.) outside diameter tubing, carbon steel in the unsaturated zone, stainless steel within and extending 25 to 30 m (80 to 100 ft) above the saturated zone.

	Lower Piezometer (String #1)		Upper Piezometer (String #2)	
Total Depth:	239.6 m	(786 ft)	191.5 m	(628 ft)
Depth Slotted Section:	227.2 to 233.3 m	(745 to 765 ft)	179.1 to 185.2 m	(588 to 608 ft)
Depth of Gravel Pack:	206.3 to 240.8 m	(677 to 790 ft)	123.4 to 191.5 m	(405 to 628 ft)
Depth, Moyno® Pump Stator:	197.9 to 202.6 m	(649 to 665 ft)	174.1 to 178.8 m	(571 to 587 ft)
Water Depth[a]:	138.1 m	(452.9 ft)	138.0 m	(452.8 ft)

DRILLING CONTRACTOR: Reynolds Electrical & Engineering Co., Inc.

GEOPHYSICAL LOGS BY: Atlas Wireline Services, Desert Research Institute, Barbour Well Surveying, Los Alamos National Laboratory/Lawrence Livermore National Laboratory

SURVEYING CONTRACTOR Raytheon Services Nevada

[a]Fluid levels as of 06/21/94.

(500 to 600 gallons per minute [gpm]) had filled the existing on-site lined sump and infiltration basin to near capacity. Drilling fluids were trucked to the Well ER-19-1 infiltration basin.

On March 16, 1994, an attempt was made to resume drilling with a downhole Dyna-Drill™ and a new 31.1-cm (12¼-in.) bit; the attempt was unsuccessful, so drilling resumed with the original 31.1-cm (12¼-in.) bit and conventional downhole assembly. Drilling continued to 434.6 m (1,426 ft), at which point circulation was lost and the drilling assembly became stuck. After approximately 24 hours, efforts to free the drilling assembly were successful, and the assembly was removed from the borehole. The bit was run back into the borehole after a caliper tool could go no deeper than 290.2 m (952 ft). The obstruction encountered at 290.2 m (952 ft) was drilled through, and the bit was lowered to 384.7 m (1,262 ft), at which point fill was encountered. No attempt was made to clean the fill, and geophysical logging began, starting with the caliper log from a depth of 384.7 m (1,262 ft).

On March 21, 1994, after encountering fill at 280.4 m (920 ft) while logging, the drill string was lowered into the borehole, and fill was cleaned to a depth of 302.4 m (992 ft). Fill was determined to be reaccumulating at a rate of 1 m per minute (3.3 ft per minute). It was decided to stop at the current depth and complete the well. The drilling assembly was removed from the hole, and geophysical logging continued. The top of the fill was determined to be at 285.0 m (935 ft).

A graphical depiction of drilling parameters, including penetration rate, revolutions per minute, pump pressure, and weight on the bit, is presented in Appendix A-2. Geophysical logs were run several times during drilling to assess borehole conditions, and the final suite of logs was completed on March 25, 1994.

The Desert Research Institute (DRI) installed time domain reflectometry (TDR) instrumentation in the fluid discharge line at the rig on Well ER-30-1 to determine the effectiveness of TDR in detecting the presence of free water in the drilling effluent. The TDR system and the results of this test are discussed in Section 5.0.

2.3 Drilling Problems

Problems experienced during drilling of Well ER-30-1 were associated with two natural conditions encountered in the borehole: (1) sloughing zones in the bedded and welded tuff intervals and (2) very high water production. Measures taken to manage problems associated with these conditions resulted in delays, and ultimately a shallower than planned TD for the hole was accepted. The following paragraphs summarize the primary consequences of sloughing and high water production at Well ER-30-1.

2.3.1 Borehole Sloughing

Hole problems in two main areas of the borehole caused drilling difficulties. The area from 246.9 to 295.0 m (810 to 968 ft) required cementing twice due to excessive erosion and sloughing of the borehole. Although this delayed the drilling process, cementing this zone stopped much of the sloughing, and drilling was able to proceed. The zone from 360.0 to 434.6 m (1,181 to 1,426 ft) washed out so that the drill pipe became stuck for several hours due to lost circulation and excessive material sloughing around the drill pipe and bit. This portion of the hole continued to slough after repeated attempts to clean the fill during geophysical logging, but cementing was not attempted. The decision to continue drilling with air foam rather than to switch to a heavier mud may have exacerbated the problem, but ultimately will make development of the well much easier.

The drilling program called for setting an intermediate casing point in the upper portion of the Ammonia Tanks Tuff, at an approximate depth of 150 to 200 m (492 to 656 ft). The purpose of the intermediate casing was to stabilize any sloughing zones in the upper part of the hole. However, the Ammonia Tanks Tuff was not penetrated until approximately 365 m (1,198 ft), well below the water table. A casing point at this depth would have eliminated a significant portion of the saturated zone in the well from consideration as a completion zone, so a decision was made not to set intermediate casing.

2.3.2 High Water Production

The first evidence of water produced from the borehole was observed at the depth of 140 m (459 ft). Below the depth of 275 m (902 ft), the water production during drilling exceeded 1.89 m^3/min (500 gpm). Thus, for every hour of drilling, roughly 114 cubic meters (714 barrels [30,000 gallons (gal)]) of fluid were produced in addition to the drilling fluid added to the hole during drilling. On-site pit capacity was nearly reached by March 14, 1995, and drilling was shut down until March 16, 1995, while accumulated drilling fluid and groundwater were hauled to the infiltration pit at Well ER-19-1. Again, use of a heavier mud to try to seal the formation might have relieved this problem to some degree. The anticipation of handling water production of this magnitude as the drill-hole depth increased contributed to the decision to stop drilling before the planned TD was reached.

2.4 *Fluid Management*

Bentonite air foam, modified to eliminate soda ash (sodium carbonate [Na_2CO_3]) from the mixture, was used during drilling of Well ER-30-1 (Appendix A-4). Fluid from the well was discharged into a lined sump and later transferred into an infiltration sump once it had been confirmed that fluid quality objectives were met. When the effluent filled the on-site storage capacity, approximately 827 cubic meters (5,200 barrels [218,400 gal]) of discharge fluid were hauled off site for disposal in Well ER-19-1 infiltration pit.

Drilling effluent was monitored in accordance with the *Fluid Management Plan for the Underground Test Area Operable Unit* (DOE, 1994b). The results of analyses on samples of drilling fluid collected at Well ER-30-1 during drilling operations indicate that all fluid quality objectives were met.

Appendix B of this report contains a fluid disposition reporting form and final analytical results. The fluid disposition form lists volumes and data from well-construction operations, Stages I through III. The volumes of fluids imported to and produced at Well ER-30-1 were calculated from vacuum-truck delivery tickets and measurements of fluids in the lined sump. The solids produced were calculated using the diameter of the borehole and the depth drilled and take into account hole sloughing, redrill of cemented intervals, and lost circulation.

3.0 Geologic Data Collection

3.1 Introduction

This section describes the scurces of geologic data obtained from Well ER-30-1 and the methods of data collection. Obtaining geologic data was one of the primary objectives of Well ER-30-1 because of the scarcity of subsurface data from this part of the NTS and especially from the Timber Mountain moat. Data from Well ER-30-1 were expected to increase understanding of the distribution of the tuffs from the Timbėr Mountain caldera and postcollapse moat-filling sediments, which may have an influence on the groundwater flow regime. Thus, the proper collection of geologic data from Well ER-30-1 was considered fundamental to successful completion of the project. Geologic data collection and sampling at Well ER-30-1 consisted of drill cuttings, sidewall core samples, and geophysical logs.

Geologic 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-30-1 at 3.05-m (10-ft) intervals as drilling progressed from the surface to the TD of the well (434.6 m [1,426 ft]), for a total of 142 samples. The IT Field Representative collected a grab sample from each of the cuttings samples before relinquishing custody to the U.S. Geological Survey (USGS) Core Library via RSN. These samples were examined at the drill site, and the field lithologic descriptions were used in preparation of the final lithologic log for Well ER-30-1 given in Appendix C.

3.3 Sidewall Core Samples

After drilling was completed two sets of percussion sidewall cores were collected by Atlas Wireline Services (AWS) on March 22, 1994, to verify the stratigraphy penetrated in the 74.7- to 240.8-m (245- to 790-ft) interval. Core sample depths were determined by the IT Field Representative and the IT Field Manager in consultation with RSN geologists and logging engineers. Samples were taken when lithologic data were needed after analysis of penetration-rate changes, geophysical logs (to identify lithologic boundaries), and caliper logs (for successful operation of the sidewall tool). Because erosion of the borehole wall made retrieval of the sidewall samples difficult, up to four samples were attempted at each sample depth to increase chances of recovery.

Thirteen 20-millimeter (0.8-in.) diameter sidewall cores were recovered out of 25 attempted. The sidewall cores were transferred to the USGS Core Library in Mercury, Nevada, by RSN. Table 3-1 summarizes sidewall-core sample depths and recovery.

3.4 Geophysical Data

Geophysical logs were run at various stages of drilling and well completion to further characterize the lithology, structure, and water content of the formations encountered. Geophysical logs were also run to check hole conditions and to determine the extent of caving, the depth to water prior to cementing, and fluid levels during the course of drilling and to monitor completion progress. All logs run are listed in Table 3-2. Geophysical logs used in geologic interpretation are presented as a composite log in Appendix D. In addition to the "standard" suite of logs, AWS conducted a seismic-check shot survey, Barbour Well Surveying ran a downhole video televiewer camera survey, and DRI collected thermal flow data.

Geophysical logs from Well ER-30-1 are available from RSN in Mercury, Nevada, or the Well ER-30-1 project files maintained by IT in Las Vegas, Nevada.

Table 3-1
Sidewall Core Samples Collected at Well ER-30-1

Sidewall Cores			
Core Depth meters (feet)	**Recovery**	**Length Recovered** centimeters (inches)	**Stratigraphy**
74.7 (245)	Recovered	3.8 (1.5)	Alluvium
74.7 (245)	Recovered	3.8 (1.5)	Alluvium
91.4 (300)	Recovered	3.8 (1.5)	Alluvium
91.4 (300)	Recovered	3.6 (1.4)	Alluvium
104.5 (343)	Recovered	1.3 (0.5)	post-caldera moat-filling sediments
123.1 (404)	Recovered	2.8 (1.1)	Basalt of Dome Mt.
123.1 (404)	Recovered	2.8 (1.1)	Basalt of Dome Mt.
139.6 (458)	Recovered	2.0 (0.8)	Basalt of Dome Mt.
139.6 (458)	Unrecovered	0.0	--
159.7 (524)	Unrecovered	0.0	--
159.7 (524)	Unrecovered	0.0	--
167.6 (550)	Unrecovered	0.0	--
167.6 (550)	Unrecovered	0.0	--
196.3 (644)	Unrecovered	0.0	--
196.3 (644)	Unrecovered	0.0	--
218.2 (716)	Unrecovered	0.0	--
218.2 (716)	Unrecovered	0.0	--
218.2 (716)	Unrecovered	0.0	--
218.2 (716)	Unrecovered	0.0	--
230.4 (756)	Unrecovered	0.0	--
230.4 (756)	Recovered	2.5 (1.0)	post-caldera moat-filling sediments
230.4 (756)	Recovered	3.3 (1.3)	post-caldera moat-filling sediments
240.8 (790)	Recovered	2.3 (0.9)	Rhyolite of Chukar Canyon
240.8 (790)	Recovered	3.3 (1.3)	Rhyolite of Chukar Canyon
240.8 (790)	Recovered	3.6 (1.4)	Rhyolite of Chukar Canyon

Sidewall Core Type - Percussion-Gun: Series 1812 CM Corgun
Operator - Atlas Wireline Services

Table 3-2
Well ER-30-1 Geophysical Log Summary
(Page 1 of 2)

Geophysical Log Type	Log Purpose	Logging Service	Date Logged	Run Number	Bottom of Logged Interval meters (feet)	Top of Logged Interval meters (feet)
Compensated Acoustilog/ Gamma Ray	Determination of fracture characteristics/stratigraphic correlation	AWS[a]	03/21/94	AC-1/GR-8	284.7 (934)	140.2 (460)
Borehole Seismic Analysis (air gun)	Lithologic determination	AWS	03/23/94	SGG-1	280.4 (920)	38.1 (125)
Caliper/Gamma Ray	Hole conditions, cement volumes/stratigraphic correlation	AWS	03/08/94 03/09/94 03/10/94 03/17/94 03/18/94	CA6-1/GR-1 CA6-2/GR-2 CA6-3/GR-3 CA6-4/GR-4 CA6-5/GR-5	264.9 (869) 271.6 (891) 290.8 (954) 283.2 (929) 381.9 (1,253)	16.8 (55) 209.7 (688) 14.3 (47) 15.2 (50) 15.2 (50)
Compensated Density/Gamma Ray	Lithologic determination/ stratigraphic correlation	AWS	03/21/94	CDL-1/GR-7	289.0 (948)	28.7 (94)
Downhole-Oriented Color Video	Borehole examination for fractures, lithology, and fluid flow	Barbour[b]	03/24/94	TV-1	285.0 (935)	0
Dual Induction (focused)/ Gamma Ray	Rock porosity/lithologic determination	AWS	03/21/94	DIFL-1/GR-6	289.0 (948)	31.1 (102)
Dual Lateralog/Gamma Ray	Water saturation (sat. zone)/ stratigraphic correlation	AWS	03/22/94	DLL-1/GR-12	286.0 (938)	129.6 (425)
Epithermal Neutron-Porosity/Gamma Ray	Total water content/ stratigraphic correlation	AWS AWS	03/22/94 03/22/94	ENP-1/GR-10 ENP-2/GR-11	250.6 (822) 285.0 (935)	21.0 (69) 210.3 (690)
Fluid Density	Depth to water in borehole	AWS	03/04/94 03/07/94 03/08/94 03/18/94	DF-1 DF-2 DF-3 DF-4	154.8 (508) 155.4 (510) 157.3 (516) 143.3 (470)	138.1 (453) 135.9 (446) 131.4 (431) 119.5 (392)
Fraclog/Gamma Ray	Fracture determination, rock permeability estimation/ stratigraphic correlation	AWS	03/21/94	FRAC-1/GR-9	282.6 (927)	139.6 (458)

Refer to footnotes at end of table.

Table 3-2
Well ER-30-1 Geophysical Log Summary
(Page 2 of 2)

Geophysical Log Type	Log Purpose	Logging Service	Date Logged	Run Number	Bottom of Logged Interval meters (feet)	Top of Logged Interval meters (feet)
Gyroscopic Survey	Borehole deviation	BHI[c]	05/11/94	DRG-1	194.5 (638)	0
Percussion Gun Sidewall Core	Geologic samples, geophysical log calibration	AWS	03/22/94	SGUN-1, 2	240.8 (790)	74.7 (245)
Photon Annulus Investigation (nuclear)	Omnidirectional density (check for cement and/or fluid location)	AWS	03/08/94 03/09/94 03/10/94 03/10/94 03/24/94 03/24/94 03/25/94 03/25/94	AIN-1 AIN-2 AIN-3 AIN-4 AIN-5 AIN-6 AIN-7 AIN-8	252.7 (829) 254.2 (834) 277.1 (909) 268.5 (881) 246.3 (808) 197.2 (647) 196.0 (643) 190.2 (624)	235.3 (772) 238.4 (782) 255.4 (838) 225.6 (740) 206.7 (678) 98.8 (324) 88.4 (290) 0
Spectral Gamma Ray	Stratigraphic correlation, mineralogy, natural radiation	AWS	03/18/94	SGR-1	381.0 (1,250)	30.5 (100)
Temperature	Groundwater temperature	AWS AWS	03/18/94 03/21/94	TL-1 TL-2	383.4 (1,258) 284.1 (932)	26.8 (88) 26.2 (86)
Thermal Flow (with temperature, electrical conductivity, and pH)	Rate/direction of groundwater flow	DRI[d]	03/22/94	1	289.3 (949)	139.0 (456)
Total Magnetic Intensity	Stratigraphic correlation	LANL/LLNL[e]	03/22/94	MPP-1	288.0 (945)	36.0 (118)

[a] Atlas Wireline Services
[b] Barbour Well Surveying
[c] Baker Hughes INTEQ
[d] Desert Research Institute
[e] Los Alamos National Laboratory/Lawrence Livermore National Laboratory

4.0 Geology

Well ER-30-1 was drilled within the moat of the Timber Mountain caldera and penetrated 434.6 m (1,426 ft) of volcanic rocks and associated sediments. IT personnel prepared field lithologic descriptions of the cuttings and sidewall cores, and selected samples were sent to Los Alamos National Laboratory for petrographic and mineralogic analysis (Warren, 1994). Using these data and incorporating analysis of geophysical data, RSN geologists prepared the final lithologic and stratigraphic logs presented in Appendix C.

Quaternary alluvium and Tertiary-age post-caldera, moat-filling sediments were penetrated from the surface to a depth of 116.4 m (382 ft). These sediments overlie 101.2 m (332 ft) of basalt of Dome Mountain, which was penetrated between 116.4 and 217.6 m (382 to 714 ft). An additional 23.2 m (76 ft) of post-caldera, moat-filling sediments were penetrated below the basalt of Dome Mountain, from 217.6 to 240.8 m (714 to 790 ft). These sediments in turn overlie 48.8 m (160 ft) of bedded tuffs of the rhyolite of Chukar Canyon, which was penetrated between 240.8 and 289.6 m (790 to 950 ft). Another basalt flow, the basalt of Chukar Canyon, was penetrated below the bedded tuffs, between 289.6 and 365.2 m (950 to 1,198 ft). This 75.6-m (248-ft) thick basalt flow was deposited on moderately welded ash-flow tuff of the mafic-rich portion of Ammonia Tanks Tuff, which makes up the rest of the stratigraphic section encountered in Well ER-30-1.

The geology encountered at Well ER-30-1 differed from that predicted prior to drilling (IT, 1994). The most significant differences are the presence of two basalt flows above the Ammonia Tanks Tuff and the presence of Ammonia Tanks Tuff 205 m (674 ft) deeper than expected. Such differences between predicted and actual geology encountered at Well ER-30-1 are not surprising for two reasons: (1) relationships between volcanic and sedimentary processes associated with caldera formation and collapse can be very complex, and (2) very few drill holes are located nearby to provide geologic data upon which to base predictions. The stratigraphic contacts are shown compared with the predicted stratigraphy on Figure 4-1 (IT, 1994).

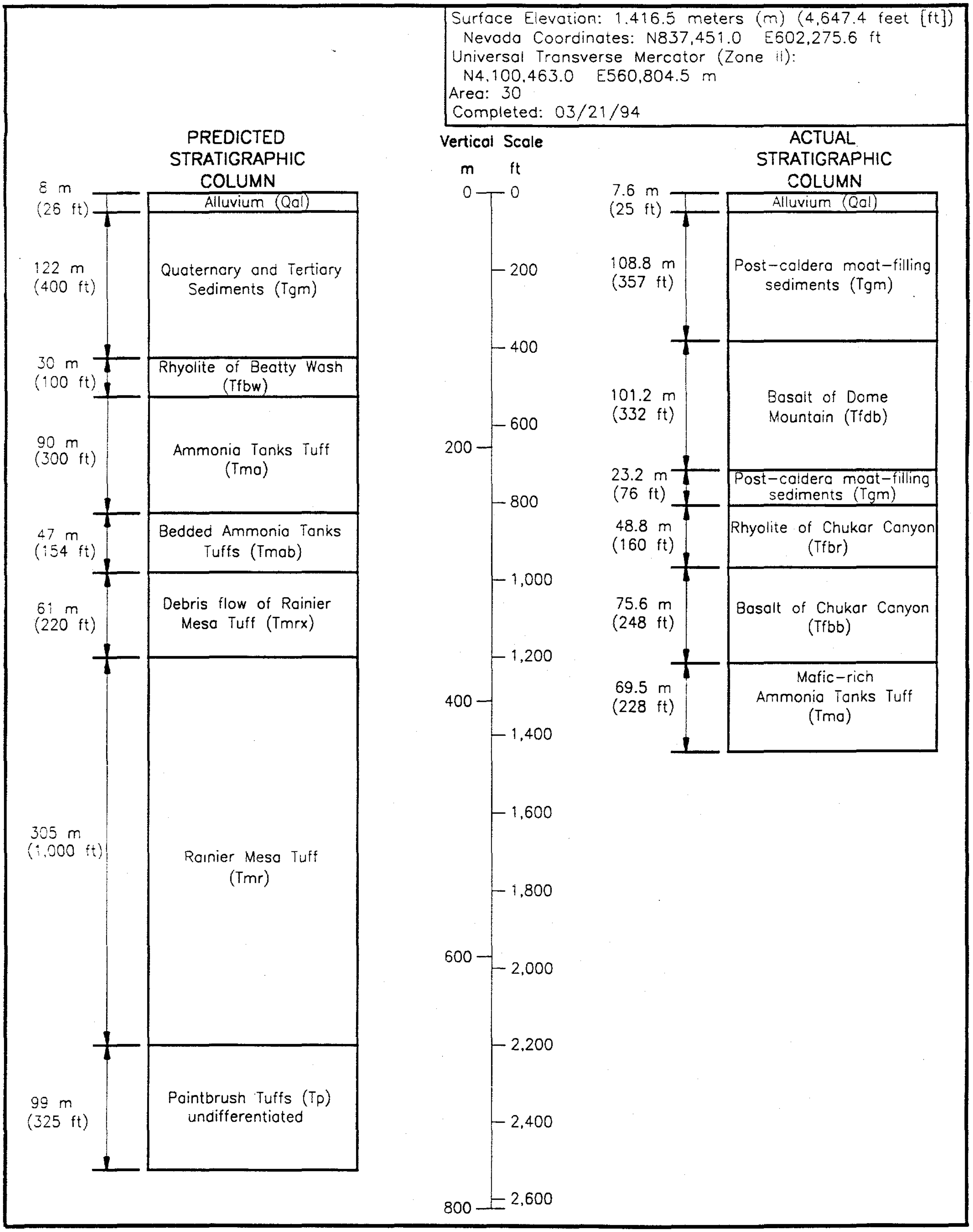

Figure 4-1
Well ER-30-1 Predicted versus Actual Stratigraphy

5.0 Hydrology

5.1 Water-Level Information

The depth to water at Well ER-30-1 was projected to be 170 ± 30 m (560 ± 100 ft), based on sparse hydrologic data for this region (IT, 1994). Drilling with air foam produced dry returns in the unsaturated zone, which enabled water to be detected almost immediately upon drilling through the water table. Groundwater was detected during drilling as early as 140 m (459 ft) by DRI's TDR system and was measured at a depth of 137.7 m (452 ft) by AWS during the course of well-construction logging. Observations made on June 21, 1994, indicated fluid levels of 138 m (453 ft) in both piezometer strings.

5.2 Water Production

Below the depth of 275 m (902 ft), water production during drilling exceeded 1.8 m^3/min (500 gpm). Thus, for every hour of drilling, the hole produced approximately 114 m^3 (30,000 gal) of water. The high volume of water produced from the borehole was due to the inflow of water to the borehole from several highly permeable water producing zones. Water production rates encountered during drilling are shown in Figure 5-1.

5.3 Time Domain Reflectometry Test

Time domain reflectometry instrumentation designed to detect the presence of water in the drilling effluent was tested by DRI during drilling of Well ER-30-1. The sensor was a modified two-wire TDR probe designed to fit within the drill rig's fluid discharge line. Time domain reflectometry monitoring began at the depth of 75 m (246 ft) and continued to 200 m (656 ft), where the well began to produce visually detectable amounts of water. The TDR response indicated wetter fluid starting at approximately 140 m (459 ft), but below 160 m (525 ft), the readings indicated drier returns. By analyzing the drill-fluid pump rate in conjunction with the TDR data, DRI estimated that the water table was penetrated at approximately 140 m (459 ft). Desert Research Institute concluded that without the pump-stroke measurements, TDR data alone were not a useful indicator of water-table penetration (Hokett et al., 1994).

5.4 Thermal Flow Meter Data

Desert Research Institute personnel made thermal flow meter (TFM) measurements at seven locations in the ER-30-1 drill hole. Temperature, electrical conductivity, and pH were also measured for use in analysis of the TFM data. These measurements were made in the effort to

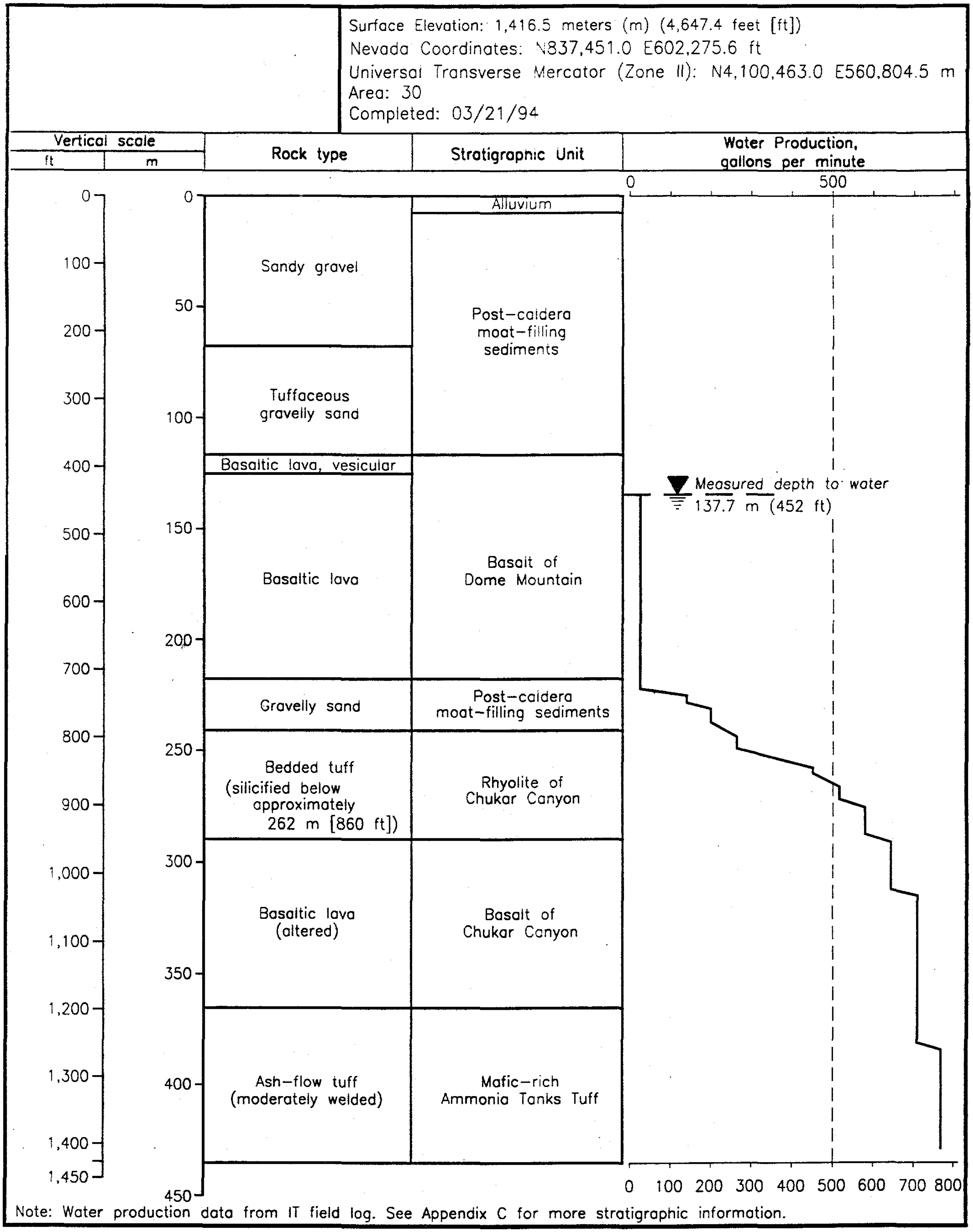

Figure 5-1
Water Production versus Lithology for Well ER-30-1

identify borehole fluid variability, which may indicate inflow and outflow zones, and to measure the water level. Analysis of the TFM and accompanying data indicated downward flow within the borehole from the water table to 164 m (538 ft) and gradually decreasing upward flow from the bottom of the hole to 173 m (567 ft). Desert Research Institute concluded from this result that water was exiting the borehole between 164 and 173 m (538 to 567 ft) (Lyles et al., 1994).

6.0 Precompletion and Open-Hole Development

Precompletion open-hole development was not attempted in Well ER-30-1 due to unstable hole conditions.

7.0 Well Completion

7.1 Introduction

The objective of well completion is to hydraulically isolate specific water-producing zones within a single borehole in order to collect potentiometric and water-chemistry data from the desired producing zones. Completion activities at Well ER-30-1 began on March 24, 1994, and were concluded on March 25, 1994. Figure 7-1 is a schematic of the final well-completion design for Well ER-30-1, 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.

Well ER-30-1 was proposed as a dual-completion well to evaluate hydrologic characteristics of two separate hydrologic regimes: a shallow zone either within volcanic units or overlying saturated tuffaceous alluvial material and a second zone within deeper volcanic units. However, because the hole was drilled shallower than planned and because the lower 150 m (491 ft) of the hole was blocked by fill material, both piezometer strings were set higher than planned, as described in this section.

7.2 Well Completion Design

7.2.1 As-Built Completion Design

Both Strings #1 and #2 are composed of stainless steel, including one slotted section in each piezometer, from the bottom of the string to just above the water level, and then flush-joint carbon-steel casing to the surface. Moyno® pump stators were permanently installed in the piezometer strings so that well development and groundwater sampling would require only insertion of the pump rotor and rods. Detailed diagrams of the completion zones for String #1 and #2 are shown on Figures 7-3 and 7-4, respectively, and the string compositions summarized here are listed on Table 7-1.

The lower section of String #1 is 2⅞-in. od Type 304 stainless-steel tubing to approximately 31.4 m (103 ft) above static water level (based on a static water level in the hole of approximately 137.5 m [451 ft]). String #2 consists of stainless-steel tubing to approximately 24.9 m (81.6 ft) above the static water level. The bottom assembly of both strings is composed of a 6.1-m (20-ft) Schedule 40, stainless-steel, bull-nosed tailpipe as a sediment trap, followed by a 6.1-m (20-ft) Schedule 40, stainless-steel, slotted section. In both strings, the stainless-steel section is followed by 9.6-m-long (31.5-ft-long), 2⅞-in. od carbon-steel joints to the surface.

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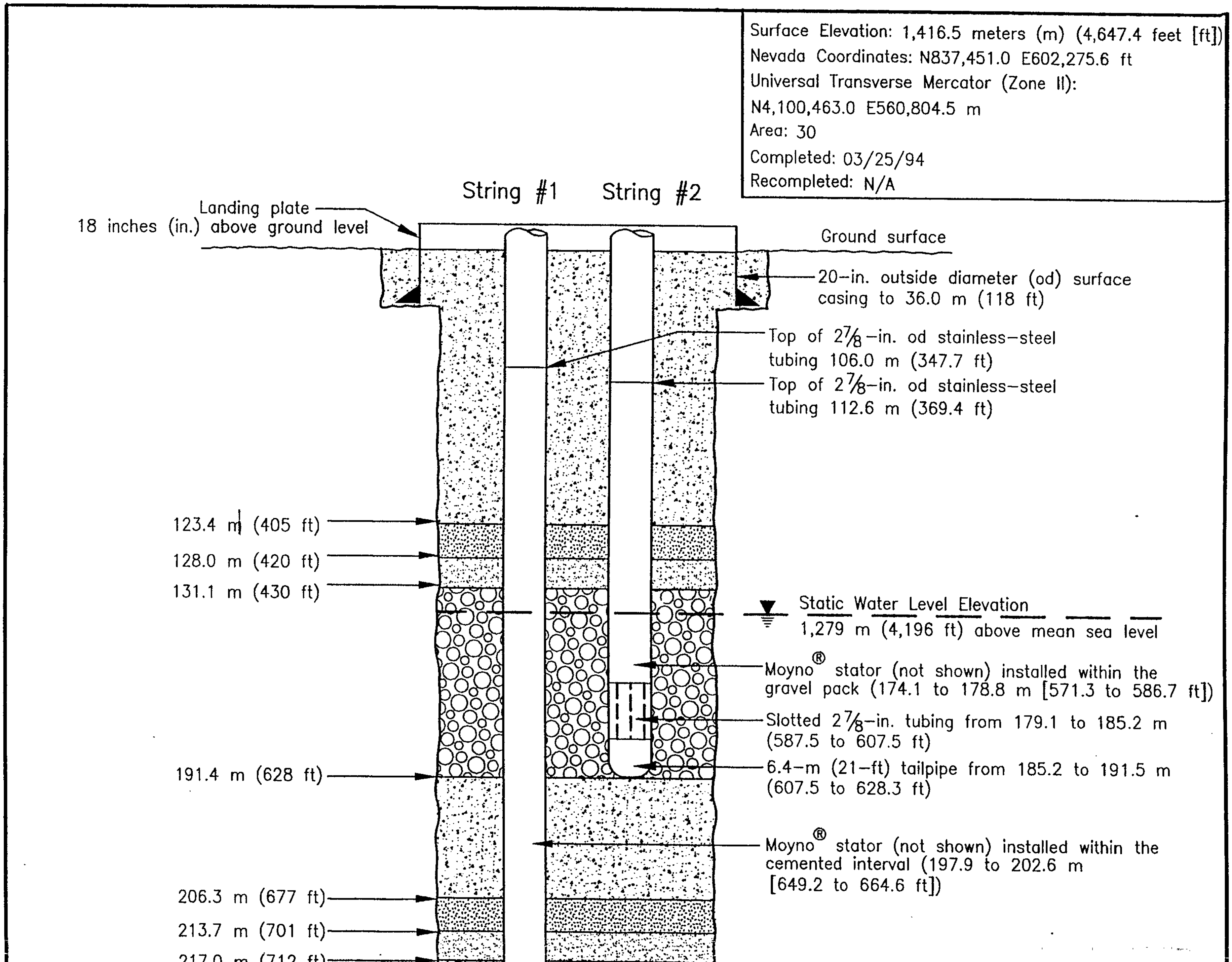

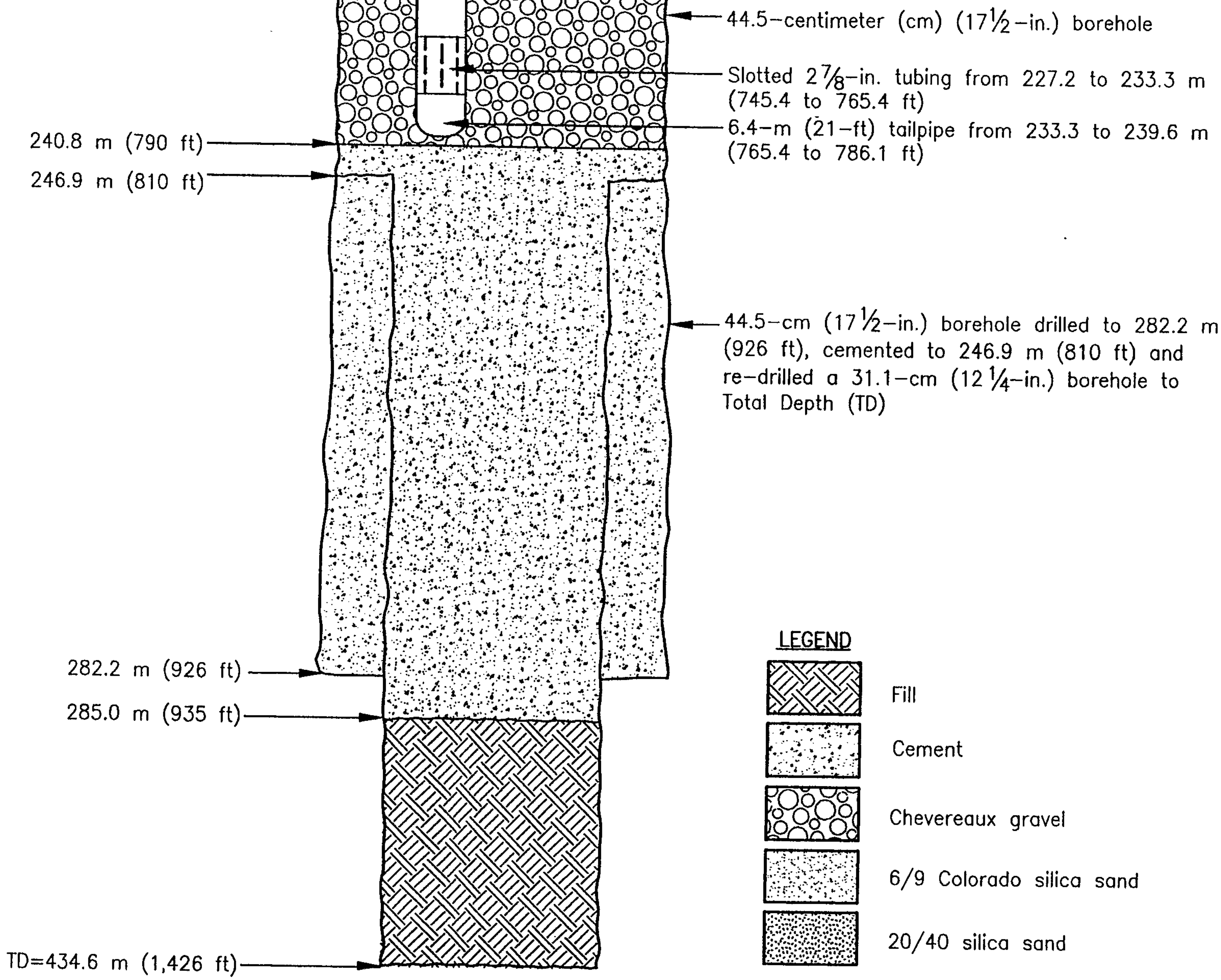

NOT TO SCALE
(All depths are below ground surface)

FIGURE 7-1
COMPLETION SCHEMATIC OF WELL ER-30-1

Additional details regarding tubing type, grade, and diameter, are provided in Appendix A-3.

Table 7-1
Well ER-30-1 Construction Summary

<table>
<tr><th rowspan="2">String</th><th colspan="3">Tubing[a]</th><th rowspan="2">Cement</th><th rowspan="2">Sand/Gravel</th><th rowspan="2">Depth to Fluid[b]</th></tr>
<tr><th>Carbon Steel</th><th colspan="2">Stainless Steel</th></tr>
<tr><td rowspan="5">#1</td><td rowspan="5">Ground surface to
106.0 meters (m) (347.7 feet [ft])</td><td rowspan="5">106.0 to 239.6 m
(347.7 to 786 1 ft)</td><td>Blank
106.0 to 197.9 m
(347.7 to 649.2 ft)</td><td rowspan="5">Type II + 2% $CaCl_2$

240.8 to 285.0 m
(790 to 935 ft)

191.5 to 206.3 m
(628 to 677 ft)</td><td>20/40 sand
206.3 to 213.7 m
(677 to 701 ft)</td><td rowspan="5">Date
06/21/94

Fluid level
138.1 m
(452.9 ft)</td></tr>
<tr><td>Moyno® stator[c]
197.9 to 202.6 m
(649.2 to 664.6 ft)</td><td rowspan="2">6-9 sand
213.7 to 217.0 m
(701 to 712 ft)</td></tr>
<tr><td>Blank
202.6 to 227.2 m
(664.6 to 745.4 ft)</td></tr>
<tr><td>Slotted
227.2 to 233.3 m
(745.4 to 765.4 ft)</td><td rowspan="2">Chevereaux gravel
217.0 to 240.8 m
(712 to 790 ft)</td></tr>
<tr><td>Bull-nosed tailpipe
233.3 to 239.6 m
(765.4 to 786.1 ft)</td></tr>
<tr><td rowspan="5">#2</td><td rowspan="5">Ground surface to
112.6 m (369.4 ft)</td><td rowspan="5">112.6 to 191.5 m
(369.4 to 628.3 ft)</td><td>Blank
112.6 to 174 1 m
(369.4 to 571.3 ft)</td><td rowspan="5">Type II + 2% $CaCl_2$

0 to 123.4 m
(0 to 405 ft)</td><td>20/40 sand
123.4 to 128.0 m
(405 to 420 ft)</td><td rowspan="5">Date
06/21/94

Fluid level
138.0 m
(452.8 ft)</td></tr>
<tr><td>Moyno® stator
174.1 to 178.8 m
(571.3 to 586.7 ft)</td><td rowspan="2">6-9 sand
128.0 to 131.1 m
(420 to 430 ft)</td></tr>
<tr><td>Blank
178.8 to 179.1 m
(586.7 to 587.5 ft)</td></tr>
<tr><td>Slotted
179.1 to 185.2 m
(587.5 to 607.5 ft)</td><td rowspan="2">Chevereaux gravel
131.1 to 191.5 m
(430 to 628 ft)</td></tr>
<tr><td>Bull-nosed tailpipe
185.2 to 191.5 m
(607.5 to 628.3 ft)</td></tr>
</table>

[a] Additional details regarding casing and tubing are provided in Appendix A-3.
[b] Fluid levels after completion. Data on actual static water levels measured during postcompletion activities will be provided in a future report.
[c] Moyno® stators are composed of carbon steel.

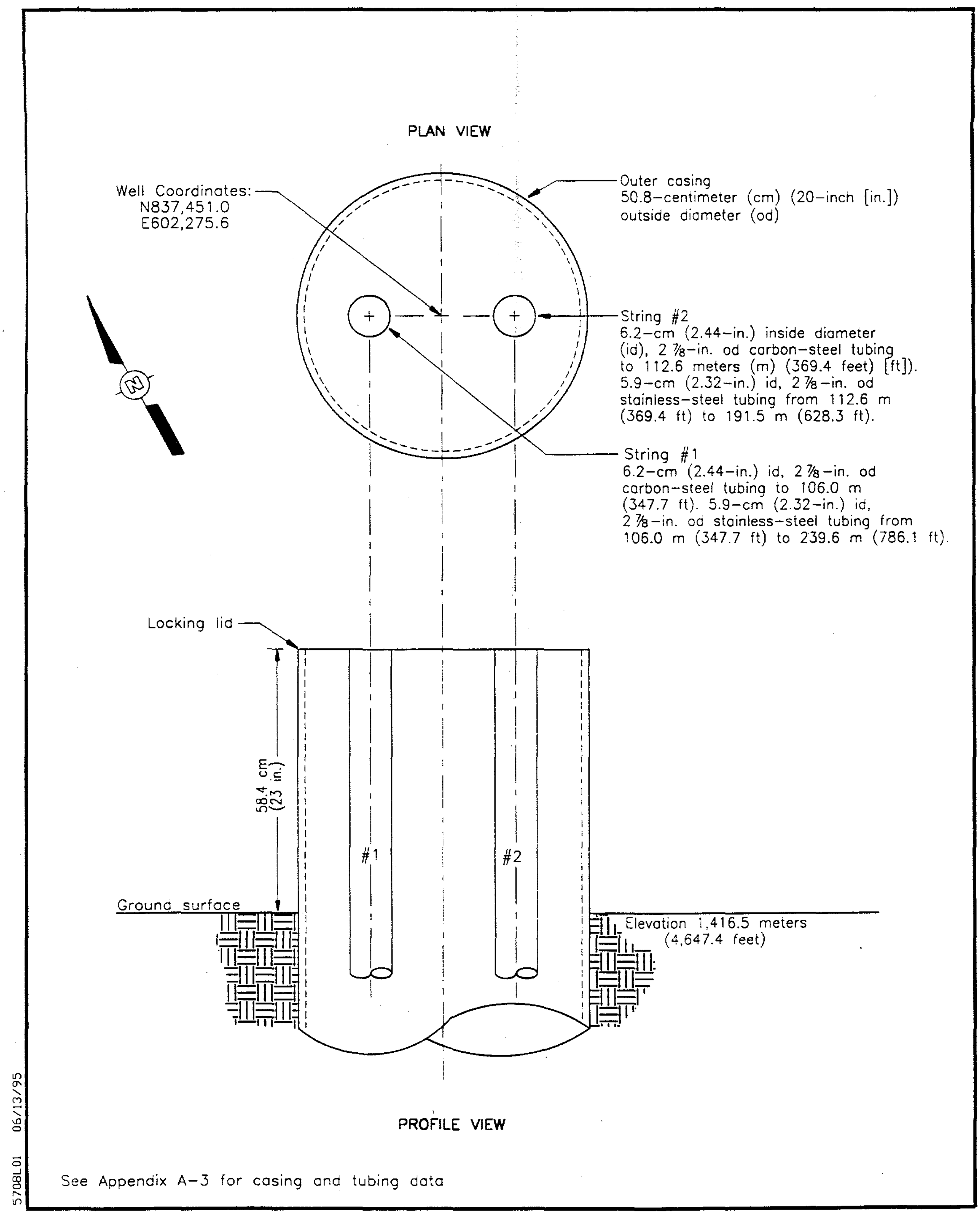

Figure 7-2
Well ER-30-1 Wellhead Diagram

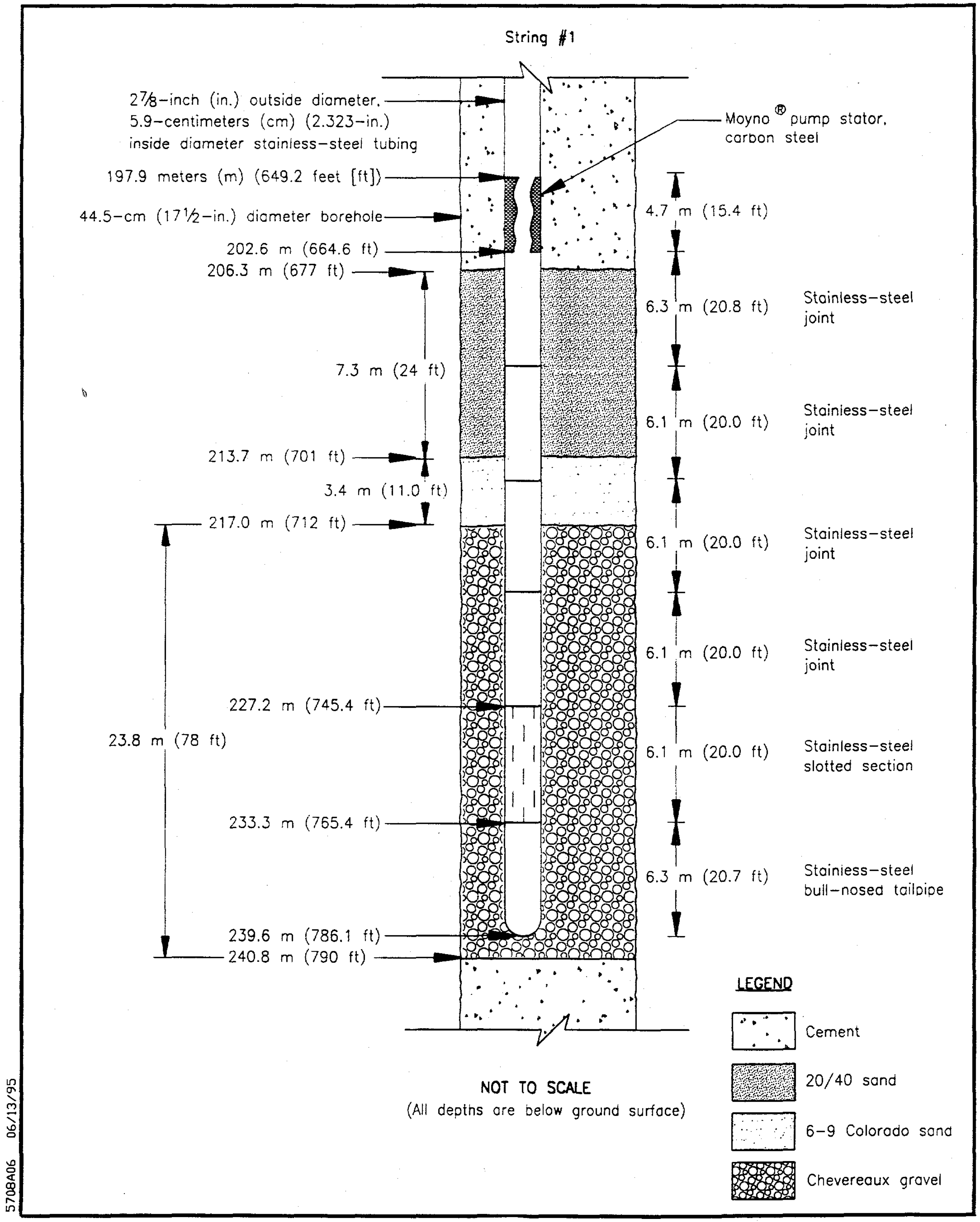

Figure 7-3
Completion Configuration for Well ER-30-1, Lower Completion Zone (String #1)

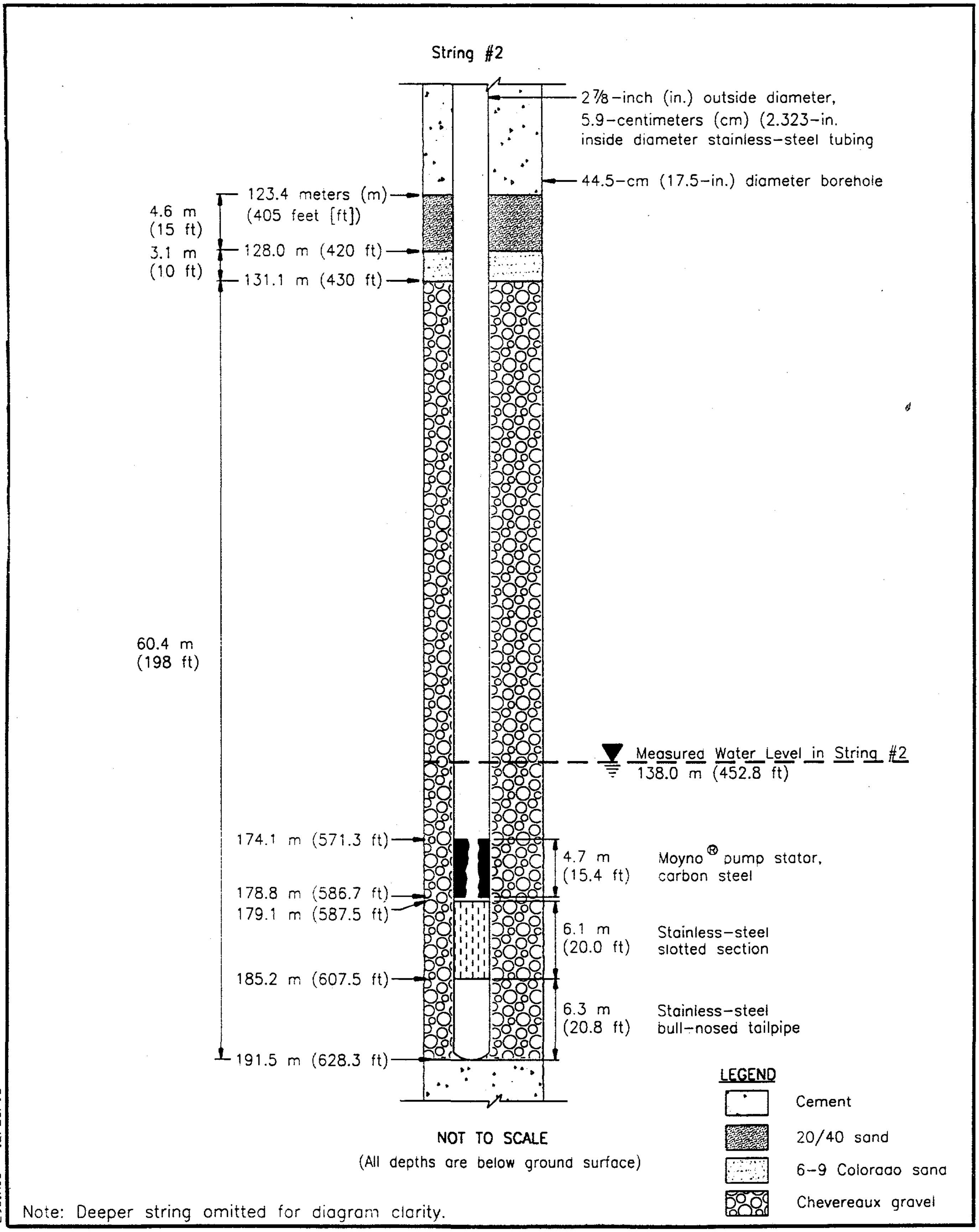

Figure 7-4
Completion Configuration for Well ER-30-1, Upper Completion Zone (String #2)

The slotted section of each piezometer, 6.1 m (20 ft) in length, contains 8 rows of saw-cut slots 7.62-cm long and 0.3-cm wide (3 in. by 0.12 in.), staggered on 30.48-cm (12-in.) centers. The slotted section and the pump stator in String #1 were separated by four solid joints (blanks) so that the stator could be encased in cement to reduce contact of its carbon-steel case with groundwater and to increase pump stability. In String #2, the gravel pack extends above the water table to allow for maximum water inflow from this zone; thus, the pump stator was placed just 0.3 m (0.8 ft) above the slotted section to allow for maximum available drawdown during pumping of the string. Cementing the stator in place was not possible in this configuration.

7.2.2 Rationale for Differences between Actual and Proposed Well Design

The well-completion design and the program criteria were specified based on the planned hole depth of 609.6 m (2,000 ft) (IT, 1994; RSN, 1994a,b). The original program specified that String #1 be set near the bottom of the well and the depth of String #2 be determined by the depth of the water table. Borehole conditions forced the completion program to be redesigned, as follows:

- The completion depth of Well ER-30-1 was 321.5 m (1,055 ft) shallower than desired and, as a result, String #1 was landed 239.6 m (786 ft) higher than anticipated. The completion strings were placed 48.2 m (158 ft) apart instead of 400 m (1,310 ft) apart.
- In String #1, the Moyno® pump stator was installed 24.7 (81 ft) above the slotted section instead of 15 m (50 ft) to permit the pump to be encased in cement to increase pump stability.
- In String #2, the Moyno® stator was installed 0.3 m (0.8 ft) above the slotted section instead of 15 m (50 ft), and the gravel pack was extended above the water table to allow for maximum water inflow from this zone.

Selection of the two intervals in which the piezometers were installed was based on their water production potential, their relative positions within the wellbore, the accessibility of the zones without cleaning fill material, and a desired minimum separation distance between the two piezometer screens.

7.3 Well Completion Methods

7.3.1 Introduction

The two completion zones in Well ER-30-1 were gravel-packed and then isolated from each other and the rest of the borehole by means of sand and cement barriers. Well-construction materials were inspected in accordance with relevant procedures; standard decontamination procedures were employed to prevent introduction of contaminants into the well. Caliper logs were used to calculate the volumes of cement needed during well completion. The Photon Annulus Investigation Log was used to monitor the rise in cement and the placement of sand and gravel.

7.3.2 Completion Method

The filter packs for both Strings #1 and #2 consisted of Chevereaux gravel, with 6/9 Colorado sand and 20-40 silica sand placed on top to prevent infiltration of cement into the screened interval. As-built measurements for both strings are shown on Figures 7-3 and 7-4.

A "tremie" line consisting of 2⅞-in. od Hydril® tubing was tripped into the hole and used for emplacement of all sand, gravel, and cement. The hole was cemented from the top of fill at 285.0 m (935 ft) to the depth of 240.8 m (790 ft) using Type II cement with 2-percent calcium chloride ($CaCl_2$). String #1 was landed at 239.6 m (786.1 ft), and AWS verified the depth of the piezometer by tagging the top of the Moyno® pump stator with a sinker bar. The gravel filter pack and sand barriers were then emplaced, followed by another cement plug to 191.5 m (628 ft).

String #2 was landed at 191.5 m (628.3 ft), and the position of the top of the pump stator was verified by AWS. The gravel filter pack and sand barriers were emplaced, and well construction was completed by cementing the remainder of the hole to the surface.

8.0 Actual versus Planned Costs and Scheduling

The cost summary for Well ER-30-1 (RSN, 1994c) (based on work-order estimates) projected that drilling and completion operations would require 34 days to accomplish. The RSN projection allowed for 26 days of drilling and geophysical logging activities and 8 days of completion operations. Actual time spent drilling and logging Well ER-30-1 was 28 days, while completion required 2 days, for a total of 30 days. Although the TD of Well ER-30-1 was approximately 175 m (574 ft) shallower than planned, the added drilling time reflects time spent stabilizing the hole (see Section 2.0) and stopping drilling to haul excess water from the drill site (see Section 5.0). The shorter than expected completion time reflects the shorter than projected completion strings.

The planned cost for 26 days of drilling, geophysical logging, and materials was $685,180. The planned cost for 8 days of completion and materials was $418,315. The total planned cost for Well ER-30-1 was $1,103,495.

The actual cost of Well ER-30-1 through completion totaled $867,088 or approximately 21 percent less than the planned cost. Table 8-1 provides a comparison of the actual versus predicted costs. Figure 8-1 is a comparison of the planned versus actual drilling costs, and Figure 8-2 is a comparison of the planned versus actual completion costs. These data (taken from the RSN summary report for Fiscal Year 1994 [RSN, 1994c]) show actual costs plotted against the day the charges were received from REECo, not against actual drilling and completion days. The additional days shown for drilling and completion also reflect subsequent activities related to water-level measurements, preparation of the well for future development and vacating the site.

Table 8-1
Well ER-30-1 Planned versus Actual Costs

Activity	Planned Cost	Actual Cost	Percent Difference Actual versus Planned
Drilling and geophysical logging	$685,180	$634,000	-8%
Well completion	$418,315	$233,088	-44%
Total	$1,103,495	$867,088	-21%

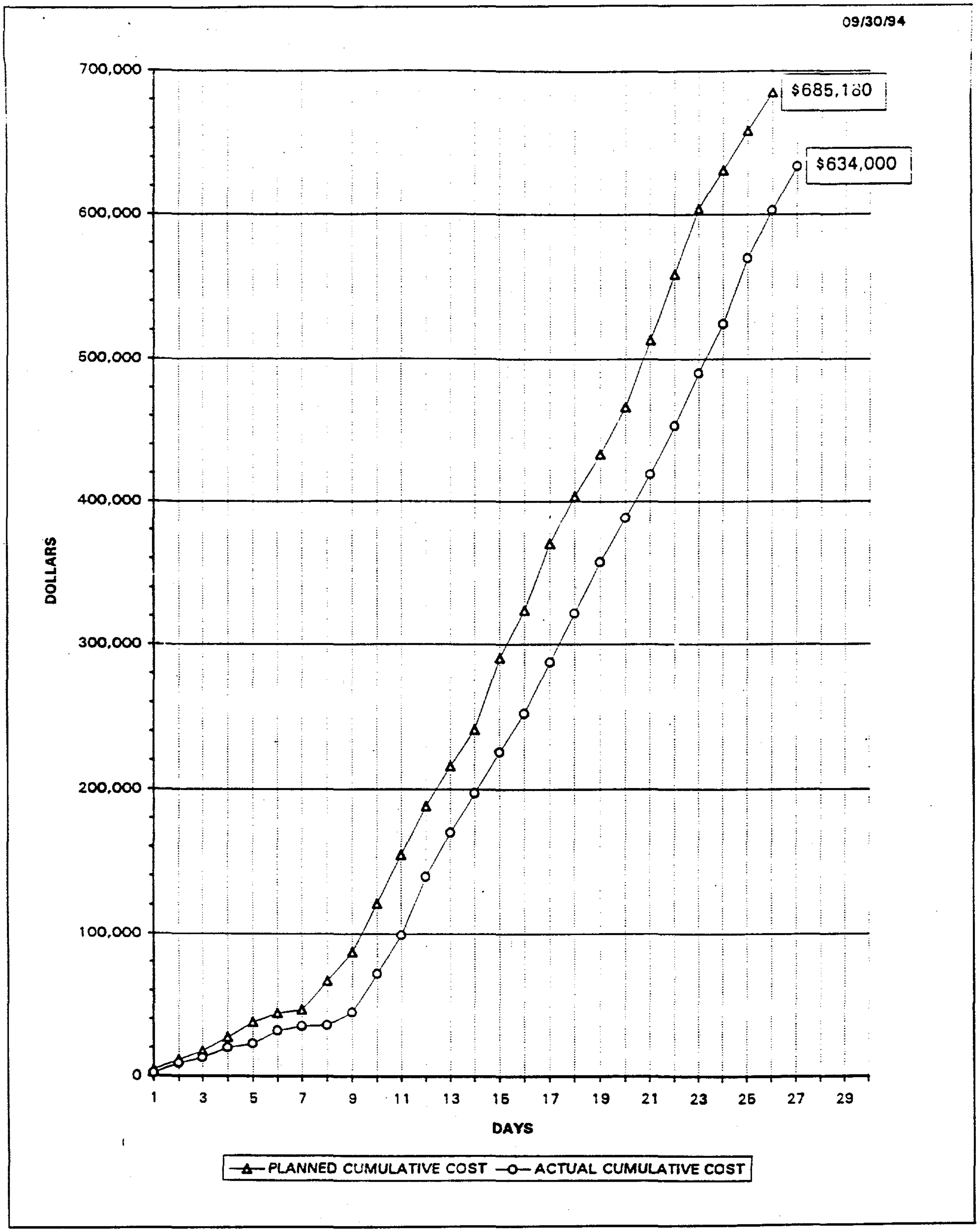

Figure 8-1
Planned versus Actual Costs for Drilling of Well ER-30-1

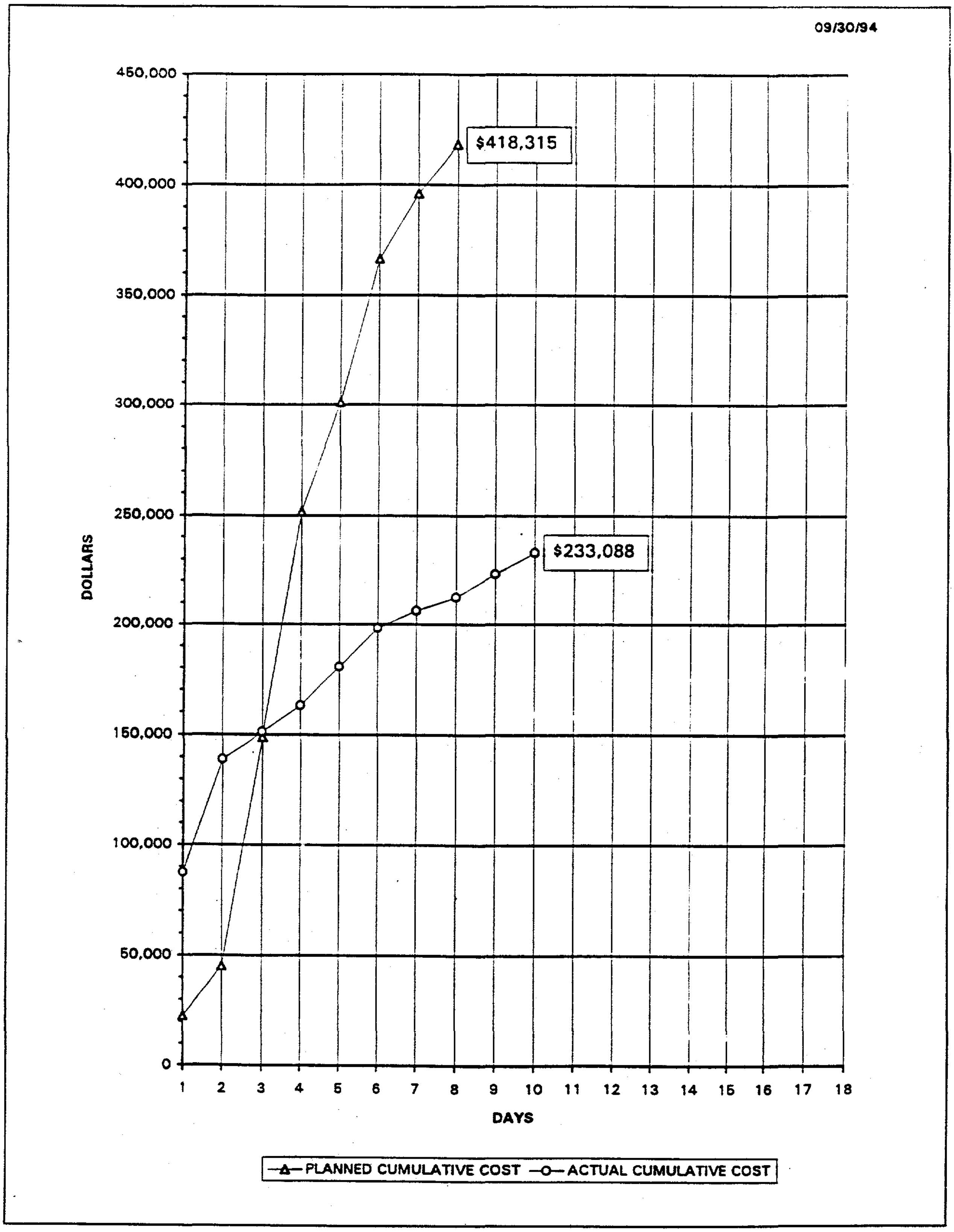

Figure 8-2
Planned versus Actual Costs for Completion of Well ER-30-1

9.0 Summary, Recommendations, and Lessons Learned

9.1 Summary

Drilling operations commenced at Well ER-30-1 on February 7, 1994, and concluded on March 21, 1994, after the TD of 434.6 m (1,426 ft) was reached. Well-completion activities were accomplished on March 24 and 25, 1995. Crews worked on a five-day-per-week, 24-hour-per-day schedule, and 30 working days were expended on well-drilling, logging, and completion activities. A ten-day drilling hiatus took place after drilling and setting the surface casing while crews worked another job.

Drilling of Well ER-30-1 took longer than expected because of time required to manage sloughing problems and to haul excess water from the rig site. Water production was first noted at the depth of 140 m (459 ft) and continued at a high rate for the remainder of drilling. Borehole sloughing problems began at the depth of 246.9 m (810 ft) and required cementing and redrilling. After the second cementing procedure, hole size was reduced from 44.5 to 31.1 cm (17½ to 12¼ in.), and the hole was drilled at the smaller size from 246.9 to 434.6 m (810 to 1,426 ft). Circulation was lost at that point, and the drilling assembly became stuck. After a day of work to free the bit and two more days of continue sloughing problems during geophysical logging, the drilled depth of 434.6 (1,426 ft) was determined to be acceptable as TD, approximately 175 m (574 ft) shallower than planned. The shallower depth was accepted because it was deemed not cost effective to continue drilling in the face of severe sloughing problems and high water production. The hole was left with 149.7 m (491 ft) of fill.

When well-completion activities began, the working depth in the borehole was 285.0 m (935 ft). Precompletion open-hole development was not attempted because of unstable hole conditions. Two piezometers were successfully installed in the borehole, although they were placed higher than planned due to the shallower hole depth. String #1 was landed at 239.6 m (786.1 ft) with one 6.1-m (20-ft) slotted interval located within gravelly volcanic sediments. String #2 was landed at 191.5 m (628.3 ft) to achieve maximum separation from String #1, but remain well below the static water level. String #2 has one 6.1-m (20-ft) slotted interval located within a water-producing basalt.

The DRI installed experimental TDR instrumentation in the fluid discharge line as part of a program to develop a method for "real-time" determination of when water is encountered during drilling. The results indicated that saturated units were penetrated at 140 m (459 ft). Three months after completion, IT measured a standing water level of 137.5 m (451 ft) in both piezometer strings.

Composite drill cuttings were collected continuously from Well ER-30-1 at 3.05-m (10-ft) intervals as drilling progressed from the surface to the TD. Thirteen percussion-gun sidewall core samples were collected at 7 locations in the borehole (sampling was attempted at 11 locations). The 142 cuttings samples and the sidewall core samples are archived at the USGS Core Library in Mercury, Nevada. Geophysical logs were run during drilling to aid in drilling and construction of the well and, after drilling was completed, to aid in verification of the geologic and hydrologic characteristics of the units. Geophysical logs for Well ER-30-1 are filed at RSN in Mercury, Nevada, and at IT, Las Vegas, Nevada.

The total estimated cost for Well ER-30-1 was $1,103,495. The actual cost was $867,088, which is approximately 21 percent less than the estimated cost.

Because drilling of Well ER-30-1 was stopped approximately 175 m (574 ft) shallower than planned, less geologic data than desired were obtained from the hole. However, the relatively high water table in this well allowed for shallower completions than originally proposed, and the overall objective of drilling and installing a well to provide hydrologic information for the western part of the NTS has been accomplished.

9.2 Recommendations for Additional Data Interpretation

The following paragraphs describe additional work needed to further interpret the geologic, hydrologic, and geophysical data gathered during drilling and completion of Well ER-30-1.

Hydrologic Analyses

Hole sloughing problems at Well ER-30-1 precluded any open-hole development, but postcompletion development was accomplished in March 1995, and one groundwater characterization sample was collected. Analysis of any subsequent water-level data is necessary to achieve the primary scientific objectives for Well ER-30-1.

Fracture Study

Analysis of geologic data, geophysical logs, and hydrologic data from Well ER-30-1 could provide insight into the hydrogeologic setting in this area of the NTS. Correlation of fracture characteristics with geophysical log data could make planning logging programs for future UGTA programs more focused, so that perhaps fewer logs could provide more useful data.

Hydrogeologic Characterization of the Timber Mountain Moat Area

The Timber Mountain moat is an important, but little understood, part of the hydrogeologic regime in the western NTS. A regional analysis of data from Well ER-30-1 and from nearby holes may be called for at this point to help understand the hydrogeologic implications of the shallow water table and the high volume of water produced at Well ER-30-1.

9.3 Lessons Learned

The following paragraphs describe lessons learned during drilling and construction of Well ER-30-1. As appropriate, these lessons can be applied to other UGTA drilling projects.

Drilling Method

The possibility of using dual-wall reverse-circulation drilling should be explored for future holes drilled in poorly consolidated materials such as alluvium and friable bedded tuff to decrease the likelihood of formation sloughing and related problems.

Drilling Fluid

The use of air-foam drilling fluid contributed to the successful construction of Well ER-30-1 because it does not leave significant residue in the formation or mudcake on the borehole walls. Also, returns to the surface during drilling are dry, making identification of the onset of groundwater production easier. However, in direct-circulation systems, the use of such a light-weight drilling fluid requires circulating at a high velocity, which can contribute to borehole erosion. Also, the air-foam mixture does not support the formation as well as a higher-viscosity fluid such as drilling mud. Every drilling project must be continuously monitored, and the trade-offs of successful drilling versus successful well development must be weighed throughout the drilling process.

Hole Sloughing

The drilling program listed a series of contingencies for dealing with borehole sloughing problems, including cementing and redrilling, and trying different drilling fluids. The setting of intermediate casing was listed as an action item in the program, but was tied to the expectation of penetrating a specific geologic formation, and was not specifically designated as a measure to minimize borehole sloughing. By the time the specified formation was penetrated in Well ER-30-1, it was judged to be too late for an intermediate casing to solve the problem without impacting the successful completion of the well. Perhaps in the future, specifications for intermediate casing should be tied to hole conditions rather than to expected geologic formations, especially where there is little geologic data for prediction of borehole conditions.

10.0 References

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Appendix A
Drilling Data

A-1 List of Records of Verbal Communication for Well ER-30-1
A-2 Drilling Parameter Log
A-3 Casing and Tubing Data for Well ER-30-1
A-4 Well ER-30-1 Drilling Fluids and Cement Composition

Appendix A-1

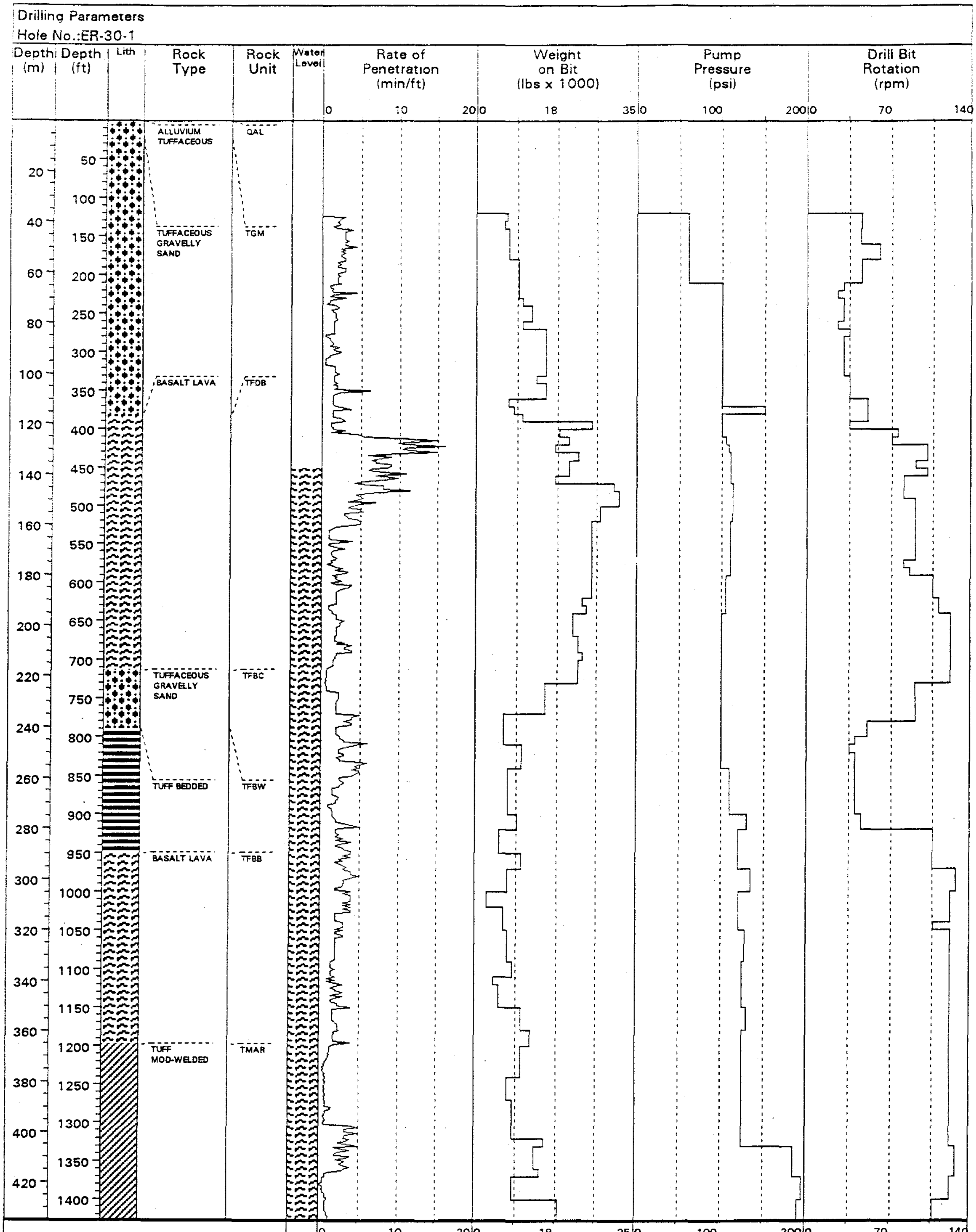
List of Records of Verbal Communication for Well ER-30-1

Appendix A-1
Raytheon Services Nevada, Record of Verbal Communications (RVC) Applicable to Well ER-30-1 Drilling and Completion

RVC#	Date	Subject
Unnumbered	03/09/94	UGTA Operable Unit Well ER-30-1: Approval to Move Fluid in Pits (Lawrence to Thompson)
RVC-0366	03/09/94	Revision to Drilling Program for UGTA Operable Unit Well ER-30-1: Drilling Program Changes
RVC-0367	03/14/94	Revision to Drilling Program for UGTA Operable Unit Well ER-30-1: Program Changes
RVC-0368	03/21/94	UGTA Operable Unit Well ER-30-1: Logging Deletion
RVC-0369	03/17/94	UGTA Operable Unit Well ER-30-1: Freepoint and Back-Off Service Requirement
RVC-0370	03/21/94	Revision to Drilling Program for UGTA Operable Unit Well ER-30-1: Total Depth Change
RVC-0372	03/22/94	UGTA Operable Unit Well ER-30-1: Additional Logging Requirements
RVC-0373	03/23/94	UGTA Operable Unit Well ER-30-1: TV Video Requirement
RVC-0374	03/29/94	Revision to Completion Program for UGTA Operable Unit Well ER-30-1: Program Changes
RVC-400	08/02/94	Workover Rig Guyline Anchors for UGTA Operable Unit Wells ER-19-1 and ER-30-1
RVC-403	09/13/94	Moyno® Rods/Rotor Installation in UGTA Operable Unit Well ER-30-1
RVC-404	09/21/94	Moyno® Work at UGTA Operable Unit Well ER-30-1

Appendix A-2

Drilling Parameter Log



See Appendix C for additional lithologic and stratigraphic data

Drilling Data Source: IT Corp. and REECo field records

Appendix A-3
Casing and Tubing Data for Well ER-30-1

Appendix A-3
Casing and Tubing Data for Well ER-30-1

CASING	Depth Interval meters (feet)	Type	Grade	Outside Diameter (inches)	Inside Diameter centimeters (inches)	Wall Thickness centimeters (inches)	Weight per foot (pound/foot)
Surface Casing	0 to 36.0 (0 to 118)	Carbon Steel	K-55	20	49.5 (19.5)	0.64 0.250	52.73
TUBING							
String #1	0 to 106.0 (0 to 347.7)	Carbon Steel Hydril®	Range 2 N-80	2⅞	6.2 (2.44)	0.55 (0.217)	6.5
String #1	106.0 to 239.6 (347.7 to 786.1)	Stainless Steel	Schedule 40	2⅞	5.9 (2.31)	0.72 (0.283)	7.66
String #2	0 to 112.6 (0 to 369.4)	Carbon Steel Hydril®	Range 2 N-80	2⅞	6.2 (2.44)	0.55 (0.217)	6.5
String #2	112.6 to 191.5 (369.4 to 628.3)	Stainless Steel	304 L Schedule 40	2⅞	5.9 (2.31)	0.72 (0.283)	7.66

Appendix A-4

Well ER-30-1 Drilling Fluids and Cement Composition

Appendix A-4
Well ER-30-1 Drilling Fluids and Cement Composition

#3 Davis Mix (Air Foam) cubic meters (m^3) (gallons [gal]) kilograms (kg) (pounds [lb])	**#10 Polymer (Air Foam)** kg (lb)	**Cement Composition**
0.22 m^3 (58 gal) detergent 907 kg (2,000 lb) bentonite 110 kg (50 lb) guar gum	13.6 (30) Baroid[a] EZ-Mud DP® air foam to suit conditions	Type II Portland cement with two-percent calcium chloride

[a]EZ-Mud DP® is a product of Baroid Drilling Fluids, Inc.

NOTES:
1. Drilling fluid mixtures consist of 19.1 cubic meters (120 barrels) per load.
2. All water used to mix drilling fluids for Well ER-30-1 came from Water Well #8.
3. A concentrated solution of lithium bromide was added to all introduced fluids to make up a final concentration of 20 to 40 milligrams per liter.

Appendix B

Well ER-30-1 Fluid Management Status Report

ER FLUID DISPOSITION STATUS REPORTING FORM

Site Identification: ER-30-1
Site Location: Area 30 - NTS
Site Coordinates: N837,450/E602,276
Well Classification: New Shallow Water Level Well
IT Project No: 301957.08020000

Report Date: 03/22/94
DOE/NV Project Manager: S. Lawrence
IT Project Manager: J. Eberlin
IT Site Representative: J. Wurtz
IT Waste Coordinator: L. Cardenas

Well Construction Activity	Activity Duration		#Ops. Days (A)	Well Depth (m)	Import Fluid (m^3)	Lined Sump #1 (m^3)		Infiltration Sump #2 (m^3)		Infiltration Area (m^3)	Other (m^3) (C)	Fluid Quality Objectives Met?
	From	To				Solids (B)	Liquids	Solids	Liquids	Liquids		
Stage I: Vadose-Zone Drilling	03/02/94	03/04/94	3	0-197	445	26	0-	-0-	478	(D)	-0-	YES
Stage II: Saturated-Zone Drilling	03/07/94	03/21/94	11	197-435	738	87	240	-0-	4,219	(D)	*826	YES
Stage III: Initial Well Development	NA	NA	NA	285	NA	NA	NA	NA	NA	(D)	NA	NA
Stage IV: Aquifer Testing (E)	NA	NA	NA	285	NA	NA	NA	NA	NA	(D)	NA	NA
Stage V: Well Completion	03/24/94	03/25/94	2	285	NA	NA	2,236	NA	NA	(D)	NA	YES
Final Development	06/28/94 (F)	02/01/95	44									
Cumulative Totals to Date:			60	285	1,183	113	2,476	(D)	4,697	(D)	826	YES

(A) Operational days refer to the number of days that the drill rig was in operation during at least part of one shift.
(B) Solids volume estimates include calculated added volume attributed to rock bulking factors.
(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) Optional fluid management devices not installed for this well site.
(E) No aquifer testing planned for this well.
(F) Date that pumping began; installation of equipment to pump well began on 6/22/94.
NA = Not applicable; m = meters; m^3 = cubic meters.
Total Facility Capacities: Lined Sump #1 = 2,380 m^3 Infiltration Area (assuming very low/no infiltration) = 2,380 m^3

Remaining Facility Capacity (Approximate) as of 03/22/94: Sump #1 = 2,140 m^3 (90%)
*826m^3 of fluids were transported from Well ER-30-1 infiltration area to Well ER-19-1 infiltration area. Avg. Tritium = 950 pCi/ℓ

IT Authorizing Signature/Date: Michael R. O'Hagan 12-20-95

UGTA RI/FS Fluid Management Chemistry
ER-30-1

Anions & Additional Analytes

Parameter					F	pH	NO2/NO3	TDS	TOC
Fluid Quality Objectives (mg/L)					20	>2 ; <12	100	NA	NA
Site	Date	Sample ID	Type	Matrix					
ER-30-1	03/07/94	GCP00224	FMS-DL	Fluid	1.4	8.05	-	206	-
ER-30-1	03/11/94	GCP00227	FMS-DL	Fluid	0.75	9.09	-	521	-
ER-30-1	03/21/94	GCP00230	FMS-DL	Fluid	1.3	8.42	-	510	-
ER-30-1	06/28/94	GCP00261	FMS-DL	Water	1.6	-	1.6	360	-
ER-30-1	06/29/94	GCP00262	FMS-DL	GW	2.1	-	19	210	-
ER-30-1	07/05/94	GCP00263	FMS-DL	GW	1.6	-	0.41	240	-
ER-30-1	08/02/94	GCP00264	FMS-DL	GW	1.50	-	4.710	231	-
ER-30-1	08/02/94	GCP00265	FMS-DL	GW	1.53	-	4.510	224	-
ER-30-1	08/08/94	GCP00266	FMS-DL	GW	1.4	-	5.23	249	-
ER-30-1	08/15/94	GCP00268	FMS-DL	GW	1.4	-	4.52	230	-
ER-30-1	08/15/94	GCP00269	FMS-DL	GW	ND	-	4.52	592	-
ER-30-1	08/22/94	GCP00281	FMS-DL	GW	1.36	-	4.97	206	-
ER-30-1	11/04/94	GCP00283	FMS-DL	GW	1.14	-	5.88	-	-
ER-30-1	11/03/94	GCP00284	FMS-DL	GW	-	-	-	-	ND
ER-30-1	11/03/94	GCP00284RE	FMS-DL	GW	-	-	-	-	3.25
ER-30-1	11/04/94	GCP00285	FMS-DL	GW	-	-	-	-	ND
ER-30-1	11/04/94	GCP00285RE	FMS-DL	GW	-	-	-	-	5.55
ER-30-1	11/21/94	GCP00287	FMS-DL	GW	-	-	-	-	ND
ER-30-1	11/22/94	GCP00288	FMS-DL	GW	-	-	-	-	ND
ER-30-1	11/23/94	GCP00289	FMS-DL	GW	-	-	-	-	ND
ER-30-1	11/21/94	GCP00286	FMS-DL	GW	1.22	-	5.79	203	-
ER-30-1	12/06/94	GCP00290	FMS-DL	GW	1.28	-	5.79	220	-
ER-30-1	12/06/94	GCP00291	FMS-DL	GW	-	-	-	-	ND
ER-30-1	12/07/94	GCP00292	FMS-DL	GW	-	-	-	-	2.14
ER-30-1	12/08/94	GCP00293	FMS-DL	GW	-	-	-	-	ND
ER-30-1	12/09/94	GCP00294	FMS-DL	GW	-	-	-	-	ND
ER-30-1	12/13/94	GCP00295	FMS-DL	GW	1.26	-	5.85	215	-
ER-30-1	12/13/94	GCP00296	FMS-DL	GW	-	-	-	-	ND
ER-30-1	01/18/95	GCP00297	FMS-DL	GW	1.55	-	4.6	217	-
ER-30-1	01/18/95	GCP00298	FMS-DL	GW	-	-	-	-	1.03
ER-30-1	01/23/95	GCP00299	FMS-DL	GW	1.31	-	6.18	129	-
ER-30-1	03/08/94	GCP00226	FMS-SP	Fluid	1.4	8.24	-	412	-
ER-30-1	03/16/94	GCP00229	FMS-SP/DL	Fluid	<2	11.5	-	531	-
ER-30-1	03/11/94	GCP00228	QCS-FR	Water	<0.10	6.73	-	0.8	-
ER-30-1	08/08/94	GCP00267	QCS-FR	Water	ND	-	ND	24.0	-
ER-30-1	08/24/94	GCP00282	QCS-FR	Water	ND	-	ND	22.0	-

FMS-Fluid Management Sample, QCS-Quality Control Sample, DL-Discharge Line, SP-Sump Pit, FR-Field Rinsate
GW- Groundwater, NA-Not Applicable, (-)-Analysis not requested

UGTA RI/FS Fluid Management Chemistry
ER-30-1

Total Metals

Parameter					As	Ba	Cd	Cr	Hg	Pb	Se	Ag	Cu	Zn
Fluid Quality Objectives (mg/L)					0.5	20	0.05	1.0	0.02	0.5	0.5	1.0	10	50
Site	Date	Sample ID	Type	Matrix										
ER-30-1	03/07/94	GCP00224	FMS-DL	Fluid	0.33	0.14	ND	<0.016	ND	<0.12	<0.0014	ND	0.016	0.082
ER-30-1	03/11/94	GCP00227(T)	FMS-DL	Fluid	<0.14	0.050	ND	<0.016	ND	ND	<0.0014	ND	0.015	0.029
ER-30-1	03/11/94	GCP00227(D)	FMS-DL	Fluid	<0.14	<0.0060	ND	ND	ND	ND	ND	ND	0.014	0.022
ER-30-1	03/21/94	GCP00230	FMS-DL	Fluid	<0.14	0.033	ND	ND	ND	ND	<0.0014	ND	<0.0090	0.022
ER-30-1	06/28/94	GCP00261(T)	FMS-DL	Water	0.020	0.025	ND	0.026	ND	ND	0.0026	ND	-	-
ER-30-1	06/28/94	GCP00261(D)	FMS-DL	Water	0.022	0.023	ND	0.024	ND	ND	0.0022	ND	-	-
ER-30-1	06/29/94	GCP00262	FMS-DL	GW	0.014	0.0085	ND	<0.016	<0.00043	<0.12	ND	ND	-	-
ER-30-1	07/05/94	GCP00263A	FMS-DL	GW	0.018	0.0093	ND	<0.016	ND	ND	<0.0014	ND	-	-
ER-30-1	07/06/94	GCP00263	FMS-DL	GW	0.011	0.0063	ND	<0.016	ND	ND	ND	ND	-	-
ER-30-1	08/02/94	GCP00264	FMS-DL	GW	0.0109	ND	ND	ND	ND	0.0264	ND	ND	-	-
ER-30-1	08/02/94	GCP00265	FMS-DL	GW	0.0106	ND	ND	ND	ND	ND	ND	ND	-	-
ER-30-1	08/08/94	GCP00266	FMS-DL	GW	ND	ND	ND	ND	ND	ND	ND	ND	-	-
ER-30-1	08/15/94	GCP00268	FMS-DL	GW	ND	ND	ND	ND	ND	ND	ND	ND	-	-
ER-30-1	08/15/94	GCP00269	FMS-DL	GW	ND	ND	ND	ND	ND	0.17	ND	ND	-	-
ER-30-1	08/22/94	GCP00281	FMS-DL	GW	ND	ND	ND	ND	ND	ND	ND	ND	-	-
ER-30-1	11/04/94	GCP00283	FMS-DL	GW	0.009	0.012	ND	ND	ND	0.008	ND	ND	-	-
ER-30-1	11/21/94	GCP00286	FMS-DL	GW	0.0065	ND	ND	0.024	ND	ND	ND	ND	-	-
ER-30-1	12/06/94	GCP00290	FMS-DL	GW	0.008	ND	ND	ND	ND	ND	ND	ND	-	-
ER-30-1	12/13/94	GCP00295	FMS-DL	GW	0.009	ND	ND	ND	ND	ND	ND	ND	-	-
ER-30-1	01/18/95	GCP00297	FMS-DL	GW	0.012	ND	ND	0.043	ND	0.004	ND	ND	-	-
ER-30-1	01/23/95	GCP00299	FMS-DL	GW	0.011	ND	ND	ND	ND	0.018	ND	ND	-	-
ER-30-1	03/08/94	GCP00226	FMS-SP	Fluid	0.21	0.086	ND	0.0070	ND	ND	ND	ND	0.013	0.048
ER-30-1	03/16/94	GCP00229	FMS-SP/DL	Fluid	0.44	0.27	ND	0.049	0.00041	<0.12	<0.0014	ND	0.024	0.11
ER-30-1	03/11/94	GCP00228	QCS-FR	Water	ND	ND	ND	ND	ND	ND	<0.0014	ND	<0.0090	0.0094
ER-30-1	08/08/94	GCP00267	QCS-FR	Water	ND	ND	ND	ND	ND	ND	ND	ND	-	-
ER-30-1	08/24/94	GCP00282	QCS-FR	Water	ND	ND	ND	ND	ND	ND	ND	ND	-	-

FMS-Fluid Management Sample, QCS-Quality Control Sample, DL-Discharge Line, SP-Sump Pit, FR-Field Rinsate, GW-Groundwater, ND-Not Detected, (T)-Total Metals, (D)-Dissolved Metals, (-)-Analysis not Requested

UGTA RI/FS Fluid Management Chemistry
ER-30-1

Radiation Chemistry

Parameter					Gross-A	Uncertainty	Gross-B	Uncertainty	H3
Fluid Quality Objectives (pCi/L)					150	(+/-)	500	(+/-)	pCi/mL
Site	**Date**	**Sample ID**	**Type**	**Matrix**					
ER-30-1	03/07/94	GCP00224	FMS-DL	Fluid (EERF)	64.4	20.6	-	-	-
ER-30-1	03/07/94	GCP00224	FMS-DL	Fluid (900)	-	-	76.5	12.6	-
ER-30-1	03/11/94	GCP00227	FMS-DL	Fluid	1.23	2.14	(-)0.94	5.93	-
ER-30-1	03/16/94	GCP00229A	FMS-DL	Fluid (EERF)	3.37	0.93	-	-	-
ER-30-1	03/16/94	GCP00229A	FMS-DL	Fluid (900)	-	-	4.64	1.31	-
ER-30-1	03/21/94	GCP00230	FMS-DL	Fluid (EERF)	2.41	0.78	-	-	-
ER-30-1	03/21/94	GCP00230	FMS-DL	Fluid (900)	-	-	5.54	1.34	-
ER-30-1	06/28/94	GCP00261	FMS-DL	Water (EERF)	0.789	1.1	-	-	-
ER-30-1	06/28/94	GCP00261	FMS-DL	Water (900)	-	-	4.22	1.4	-
ER-30-1	06/29/94	GCP00262	FMS-DL	GW (EERF)	1.15	0.64	-	-	-
ER-30-1	06/29/94	GCP00262	FMS-DL	GW (900)	-	-	1.99	1.3	-
ER-30-1	07/05/94	GCP00263	FMS-DL	GW (EERF)	0.632	0.68	-	-	-
ER-30-1	07/05/94	GCP00263	FMS-DL	GW (900)	-	-	3.37	1.3	-
ER-30-1	08/02/94	GCP00264	FMS-DL	GW (900)	24.7	3.0	6.59	0.88	-
ER-30-1	08/02/94	GCP00265	FMS-DL	GW (900)	5.58	1.12	2.70	0.55	-
ER-30-1	08/04/94	GCP00258	FMS-DL	GW	-	-	-	-	(-)90
ER-30-1	08/12/94	GCP00266	FMS-DL	GW (900)	2.82	1.55	1.09	0.88	-
ER-30-1	08/15/94	GCP00268	FMS-DL	GW (900)	2.94	1.33	1.66	0.95	-
ER-30-1	08/15/94	GCP00269	FMS-DL	GW (900)	4.21	1.77	1.80	0.93	-
ER-30-1	08/15/94	GCP00270	FMS-DL	GW	-	-	-	-	(-) 107
ER-30-1	08/22/94	GCP00281	FMS-DL	GW (900)	3.69	0.79	2.13	0.45	-
ER-30-1	11/04/94	GCP00283	FMS-DL	GW (900)	5.96	2.48	1.18	1.15	67
ER-30-1	11/21/94	GCP00286	FMS-DL	GW (900)	9.29	2.65	117	12	-
ER-30-1	12/06/94	GCP00290	FMS-DL	GW (900)	3.17	1.57	1.52	0.95	-
ER-30-1	12/13/94	GCP00295	FMS-DL	GW (900)	(-)0.20	1.80	0.12	1.28	-
ER-30-1	01/18/95	GCP00297	FMS-DL	GW (900)	3.41	0.73	2.21	0.55	-
ER-30-1	01/23/95	GCP00299	FMS-DL	GW (900)	3.37	0.76	0.97	0.44	-
ER-30-1	03/08/94	GCP00226	FMS-SP	Fluid (EERF)	2.50	0.77	-	-	-
ER-30-1	03/08/94	GCP00226	FMS-SP	Fluid (900)	-	-	1.83	1.23	-
ER-30-1	03/17/94	GCP00229B	FMS-SP	Fluid (EERF)	0.14	0.48	-	-	-

FMS-Fluid Management Sample, QCS-Quality Control Sample, DL-Discharge Line, SP-Sump Pit, FR-Field Rinsate, U-Unfiltered, F-Filtered
GW-Groundwater, EERF-Eastern Environmental Radiation Facility, 900-EPA Method 900.0, (-)-Analysis Not Requested

UGTA RI/FS Fluid Management Chemistry
ER-30-1

Radiation Chemistry

Parameter					Gross-A	Uncertainty	Gross-B	Uncertainty	H3
Fluid Quality Objectives (pCi/L)					150	(+/-)	500	(+/-)	pCi/mL
Site	**Date**	**Sample ID**	**Type**	**Matrix**					
ER-30-1	03/17/94	GCP00229B	FMS-SP	Fluid (900)	-	-	6.28	1.35	-
ER-30-1	03/07/94	GCP00225	QCS-DL	Fluid	-	-	-	-	59.7 pCi/L
ER-30-1	03/21/94	GCP00231	QCS-DL	Fluid	-	-	-	-	(-)347 pCi/L
ER-30-1	03/11/94	GCP00228	QCS-FR	Water (EERF)	1.24	0.62	-	-	-
ER-30-1	03/11/94	GCP00228	QCS-FR	Water (900)	-	-	1.17	1.09	-
ER-30-1	08/08/94	GCP00267	QCS-FR	Water (900)	(-) 0.17	0.42	0.10	0.99	-
ER-30-1	08/24/94	GCP00282	QCS-FR	Water (900)	(-) 0.06	0.14	(-) 0.69	0.35	-

FMS-Fluid Management Sample, QCS-Quality Control Sample, DL-Discharge Line, SP-Sump Pit, FR-Field Rinsate, U-Unfiltered, F-Filtered
GW-Groundwater, EERF-Eastern Environmental Radiation Facility, 900-EPA Method 900.0, (-)-Analysis Not Requested

Appendix C

Stratigraphic and Lithologic Logs of Well ER-30-1

Stratigraphic Log of ER-30-1.
(Compiled by Lance Prothro, RSN, 4 May 1995)

Depth					Thickness	
Meters	Feet	Lithology	Stratigraphic Unit	Symbol	Meters	Feet
0 - 7.6	0 - 25	**Sandy Gravel**: Fine to boulder gravel, medium to coarse sand matrix, poorly to moderately sorted.	Alluvium	Qal	7.6	25
7.6 - 116.4	25 - 382	**Sandy Gravel and Tuffaceous Gravelly Sand**: Fine to boulder gravel, fine to coarse sand, poorly to moderately sorted.	Post-caldera moat-filling sediments	Tgm	108.8	357
116.4 - 217.6	382 - 714	**Basaltic Lava**: Porphyritic, hematitic, vesicular in upper part.	basalt of Dome Mountain,* lavas of Dome Mountain,** Volcanics of Fortymile Canyon†	Tfdb	101.2	332
217.6 - 240.8	714 - 790	**Tuffaceous Gravelly Sand**: Fine to medium sand, lesser coarse sand and gravel, poorly to moderately sorted.	Post-caldera moat-filling sediments	Tgm	23.2	76
240.8 - 289.6	790 - 950	**Bedded Tuff**: Partially zeolitized, pervasively silicified in lower part.	rhyolite of Chukar Canyon,* Beatty Wash Formation,‡ Volcanics of Fortymile Canyon	Tfbr	48.8	160

Stratigraphic Log of ER-30-1 (cont.)

Depth					Thickness	
Meters	Feet	Lithology	Stratigraphic Unit	Symbol	Meters	Feet
289.6 - 365.2	950 - 1198	**Basaltic Lava**: Aphyric, weakly vesicular, hematitic.	basalt of Chukar Canyon,* Beatty Wash Formation, Volcanics of Fortymile Canyon	Tfbb	75.6	248
365.2 - 434.6 TD	1198 - 1426 TD	**Ash-Flow Tuff**: Moderately welded, devitrified.	mafic-rich Ammonia Tanks Tuff,* Ammonia Tanks Tuff,‡ Timber Mountain Group†	Tmar	>69.5	>228

*informal member; **informal formation; †formal group; ‡formal formation

Lithologic Log of ER-30-1

(Compiled by Lance Prothro, RSN, 4 May 1995)

Unless otherwise noted, the following descriptions refer to washed cuttings samples at 3.05 m (10 ft) intervals. The lithologic descriptions follow RSN Department Procedure NTS-GEO-003 and were compiled using the IT Corp. field sample descriptions. In addition, petrographic analysis, quantitative XRD analysis, and descriptions for selected samples provided by R. G. Warren (LANL) were also used. Stratigraphic contacts and lithologic divisions are tied to geophysical logs whenever possible.

Depth Meters/(Feet)	Lithologic Description	Stratigraphic Unit
0 - 7.6 m (0 - 25 ft)	**Sandy Gravel**: Pale-yellowish-brown to moderate-yellowish-brown; poorly consolidated; moderately calcareous; fine to boulder gravel in a medium to coarse sand matrix. Gravel consists of welded tuff and rhyolite lava clasts. Sand matrix is very tuffaceous, vitric to partially zeolitized/argillized, moderately sorted, subangular to subrounded, and is composed of quartz and feldspar crystals, tuffaceous rock fragments and fine ash. Interval designation and description are based partly on outcrop data.	Alluvium
7.6 - 67.7 m (25 - 222 ft)	**Sandy Gravel**: Pale-yellowish-brown to moderate-yellowish-brown; poorly to moderately consolidated; weakly to moderately calcareous; mostly fine to boulder gravel in a fine to coarse sand matrix. Gravel consists of welded tuff and rhyolite lava clasts. Sand matrix is very tuffaceous, vitric to partially zeolitized/argillized, moderately sorted, subangular to subrounded, and is composed of quartz and feldspar crystals, welded tuff and rhyolitic lava fragments, and	Post-caldera moat-filling sediments

Lithologic Log of ER-30-1 (cont.)

Depth Meters/(Feet)	Lithologic Description	Stratigraphic Unit
7.6 - 67.7 m (25 - 222 ft) (cont.)	fine ash. Samples contain a variety of tuffaceous fragments indicating the presence of interbedded tuffaceous sands, air-fall ash deposits, and low volume ash-flow tuff deposits. Interval designation and description are based partly on outcrop data.	Post-caldera moat-filling sediments
67.7 - 116.4 m (222 - 382 ft)	**Tuffaceous Gravelly Sand**: Moderate-yellowish-brown; moderately consolidated; weakly to moderately calcareous; fine to medium sand with lesser coarse sand and gravel. Sand is very tuffaceous, vitric to partially zeolitized/argillized, poorly to moderately sorted, subangular to subrounded, and is composed of feldspar and quartz crystals, welded tuff and rhyolitic lava clasts, and fine ash. Coarser sand and gravel are composed of welded tuff, rhyolitic lava, and pumice clasts. Samples contain a variety of tuffaceous fragments indicating the presence of interbedded tuffaceous sands, air-fall ash deposits, and low volume ash-flow tuff deposits.	Post-caldera moat-filling sediments

Lithologic Log of ER-30-1 (cont.)

Depth Meters/(Feet)	Lithologic Description	Stratigraphic Unit
116.4 - 125.0 m (382 - 410 ft)	**Basaltic Lava**: Dark-reddish-brown to very-dusky-red; porphyritic; vesicular with vesicle linings and amygdules of quartz and lesser zeolitic/argillic material; hematitic; rare feldspar phenocrysts. Percussion gun sidewall core sample at 123.1 m (404 ft) is argillic.	basalt of Dome Mountain, lavas of Dome Mountain, Volcanics of Fortymile Canyon
125.0 - 217.6 m (410 - 714 ft)	**Basaltic Lava**: Very-dusky-red and brownish-black; porphyritic; hematitic; minor phenocrysts of feldspar; minor phenocrysts of olivine. White to moderate-yellow zeolite/clay occurs as feldspar replacement and coatings from approximately 182.9 - 198.1 m (600 - 650 ft). Veinlets of zeolite/clay occur from approximately 192.0 - 198.1 m (630 - 650 ft).	basalt of Dome Mountain, lavas of Dome Mountain, Volcanics of Fortymile Canyon
217.6 - 240.8 m (714 - 790 ft)	**Tuffaceous Gravelly Sand**: Moderate-yellowish-brown; moderately consolidated; weakly to moderately calcareous; fine to medium sand with lesser coarse sand and gravel. Sand is very tuffaceous, vitric to partially zeolitized/argillized, poorly to moderately sorted, subangular to subrounded, and is composed of feldspar and quartz crystals, welded tuff and rhyolitic lava clasts, and fine ash. Coarser sand and gravel is composed of welded tuff, rhyolitic lava, and pumice clasts. Samples contain a variety of tuffaceous fragments indicating the	Post-caldera moat-filling sediments

Lithologic Log of ER-30-1 (cont.)

Depth Meters/(Feet)	Lithologic Description	Stratigraphic Unit
217.6 - 240.8 m (714 - 790 ft) (cont.)	presence of interbedded tuffaceous sands, air-fall ash deposits, and low volume ash-flow tuff deposits.	Post-caldera moat-filling sediments
240.8 - 250.5 m (790 - 822 ft)	**Bedded Tuff**: Dusky-yellow; mostly zeolitized, partially vitric; laminated fine to very fine grained ash deposits; common feldspar and quartz; minor biotite; rare pale-reddish-brown lithic fragments; scarce light-brown (5YR 5/6) staining.	rhyolite of Chukar Canyon, Beatty Wash Formation, Volcanics of Fortymile Canyon
250.5 - 289.6 m (822 - 950 ft)	**Bedded Tuff**: Very-pale-orange and white to pinkish-gray; mostly zeolitized, partially vitric, becoming pervasively silicified below approximately 262.1 m (860 ft); fine to coarse grained ash deposits; conspicuous white pumice up to 5 mm to a depth of approximately 262.1 m (860 ft); rare to common feldspar with conspicuously large crystals up to 3 mm; rare to minor mafic minerals of biotite and lesser clinopyroxene; conspicuous sphene. Silicification is approximately parallel to bedding creating a color banded appearance in silicified fragments.	rhyolite of Chukar Canyon, Beatty Wash Formation, Volcanics of Fortymile Canyon

Lithologic Log of ER-30-1 (cont.)

Depth Meters/(Feet)	Lithologic Description	Stratigraphic Unit
289.6 - 365.2 m (950 - 1198 ft)	**Basaltic Lava**: Dark-reddish-brown and very-dusky-red, moderate-reddish-brown from approximately 350.5 - 356.6 m (1150 - 1170 ft); aphyric; weakly vesicular with rare amygdules and coatings of yellow-green zeolite/clay; hematitic, weakly calcareous and argillic; minor to common lath-shaped plagioclase crystals visible under high magnification from approximately 350.5 - 356.6 m (1150 - 1170 ft).	basalt of Chukar Canyon, Beatty Wash Formation, Volcanics of Fortymile Canyon
365.2 - 434.6 m (1198 - 1426 ft) TD	**Moderately Welded Ash-Flow Tuff**: Moderate-reddish-brown; devitrified; common grayish-orange-pink pumice; common felsic phenocrysts of feldspar and quartz; common biotite. Samples are heavily contaminated with lithologies from higher in the hole.	mafic-rich Ammonia Tanks Tuff, Ammonia Tanks Tuff, Timber Mountain Group

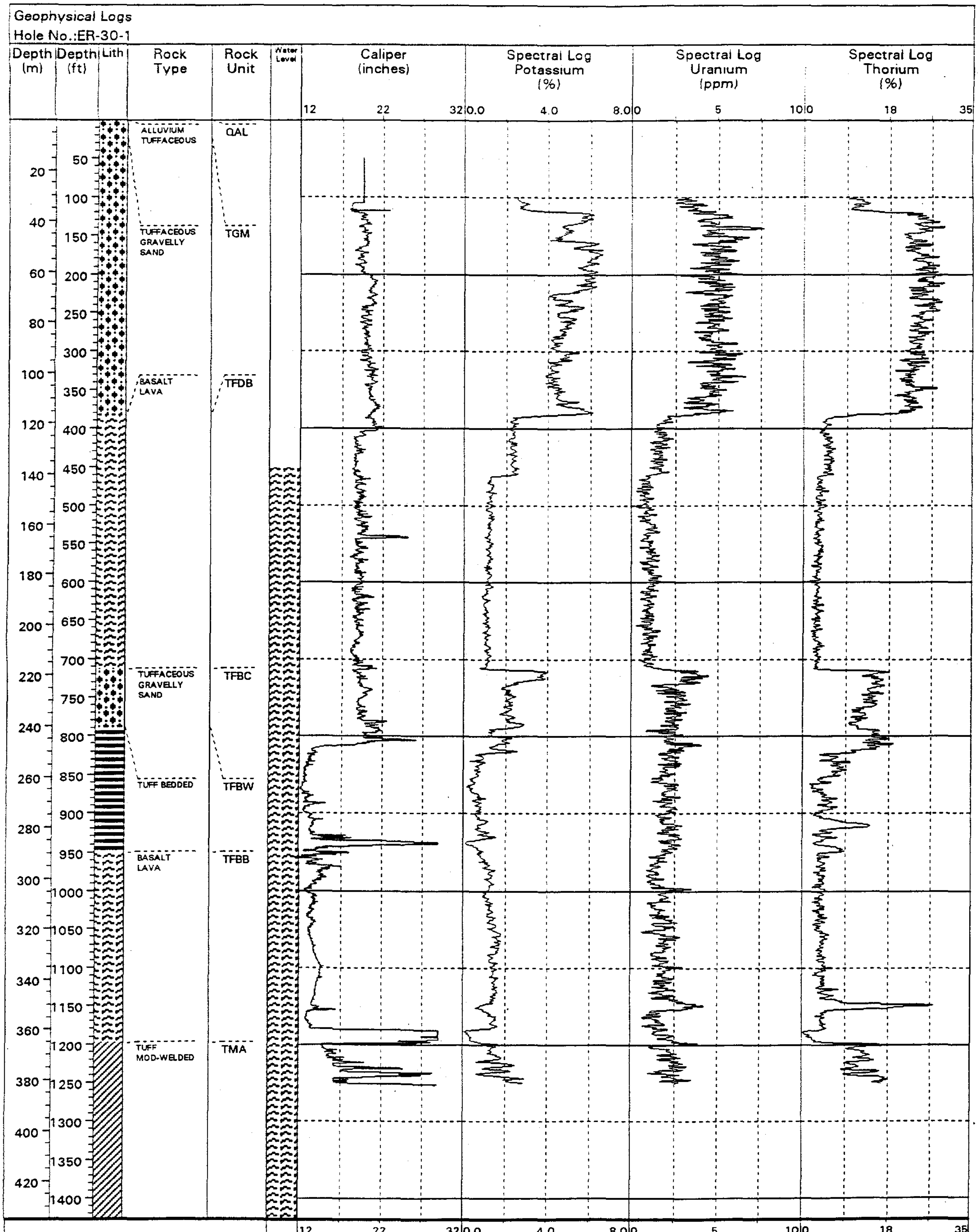
Appendix D
Geophysical Logs

Appendix D contains presentations of geophysical logs run at Well ER-30-1. Table D-1, Geophysical Log Summary, summarizes the logs presented. See Table 3-1 for more information on logs run in Well ER-30-1.

Table D-1
Geophysical Log Summary

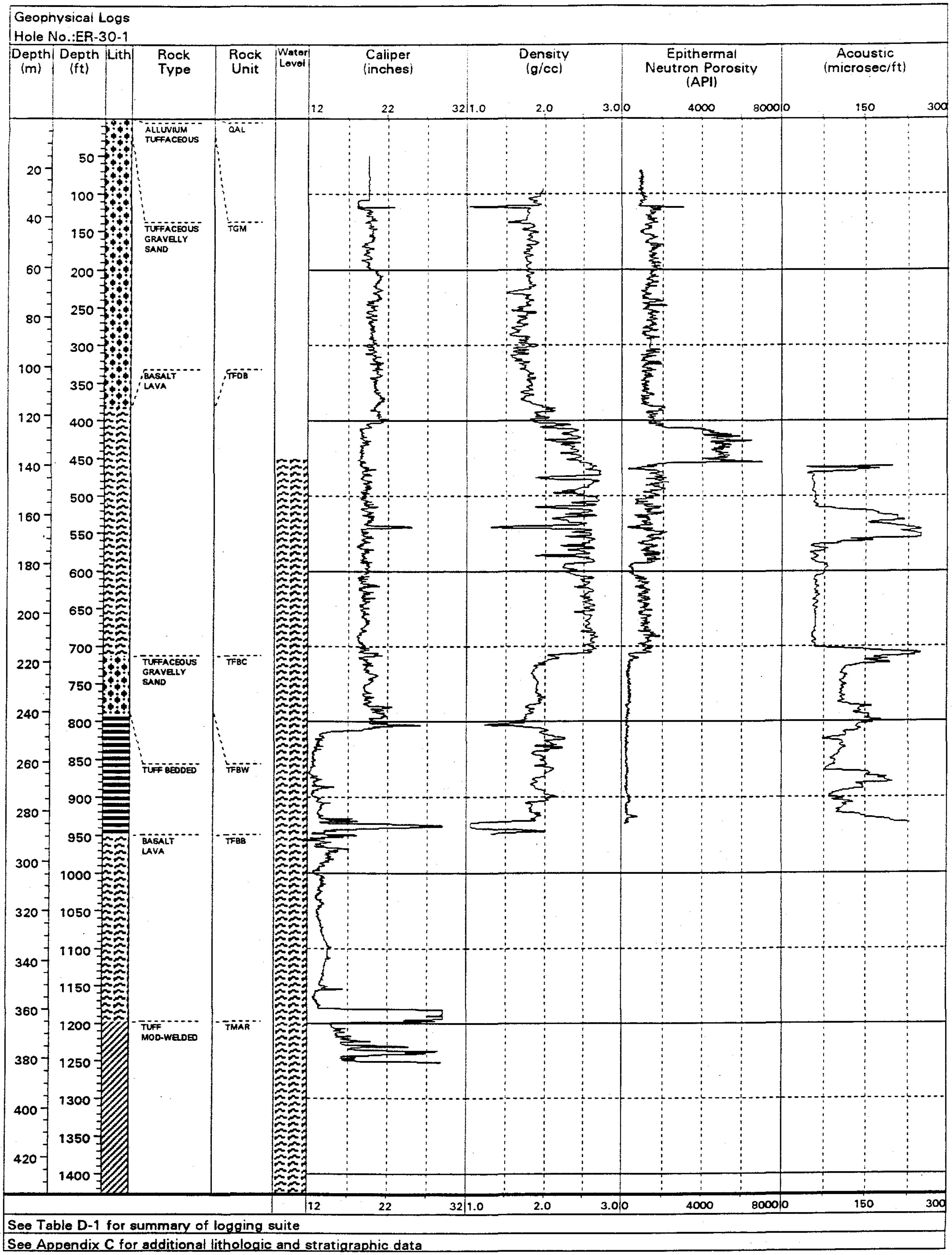
Log Type	Log Interval meters (feet)	Run #	Run Date	Sample Interval meters (feet)
Caliper	15.2 to 381.9 (50 to 1,253)	CA6-5	03/18/94	NA[a]
Density	28.7 to 289.0 (94 to 948)	CDL-1	03/21/94	NA
Epithermal Neutron Porosity [b]	21.0 to 250.6 (69 to 822) 210.3 to 285.0 (690 to 935)	ENP-1 ENP-2	03/22/94 03/22/94	NA NA
Acoustic	140.2 to 284.7 (460 to 934)	AC-1	03/21/94	NA
Spectral Gamma Ray	30.5 to 381.0 (100 to 1,250)	SGR-1	03/18/94	0.304 (1.00)
Induction	31.1 to 289.0 (102 to 948)	DIFL-1	03/21/94	0.304 (1.00)
Dual Lateral	129.5 to 285.9 (425 to 938)	DLL-1	03/22/94	0.304 (1.00)
Spontaneous Potential	129.5 to 285.9 (425 to 938)	DLL-1	03/22/94	0.304 (1.00)
Total Magnetic Intensity	36.0 to 288.0 (118 to 945)	MPP-1	03/22/94	NA
Gamma Ray	15.2 to 381.9 (50 to 1,253)	GR-5	03/18/94	0.304 (1.00)
Temperature	26.8 to 383.4 (88 to 1,258)	TL-1	03/18/94	0.304 (1.00)

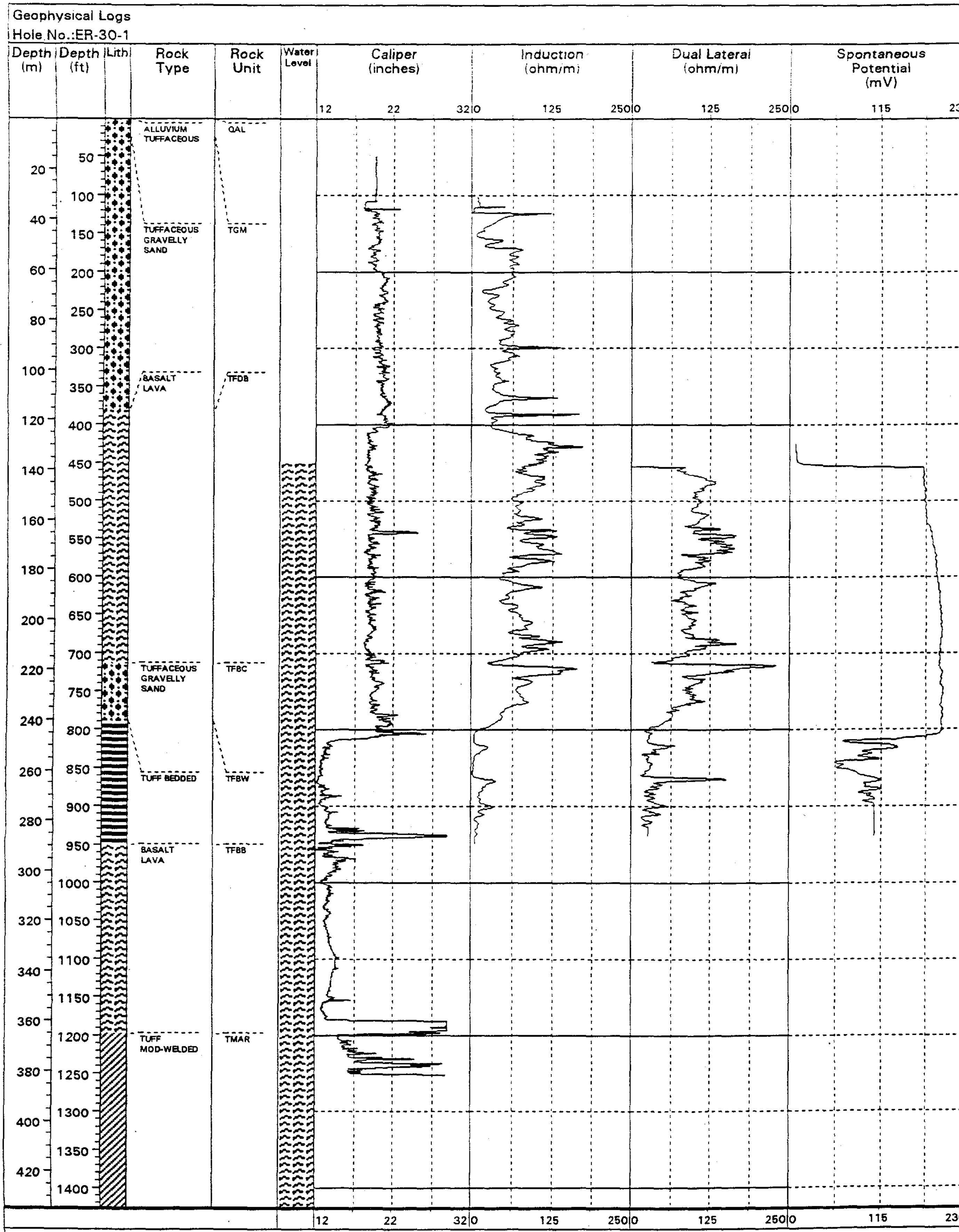
[a]Not applicable
[b]Epithermal Neutron Porosity is presented as composite log. Run ENP-2 composited at 251 m (222 ft).



See Table D-1 for summary of logging suite

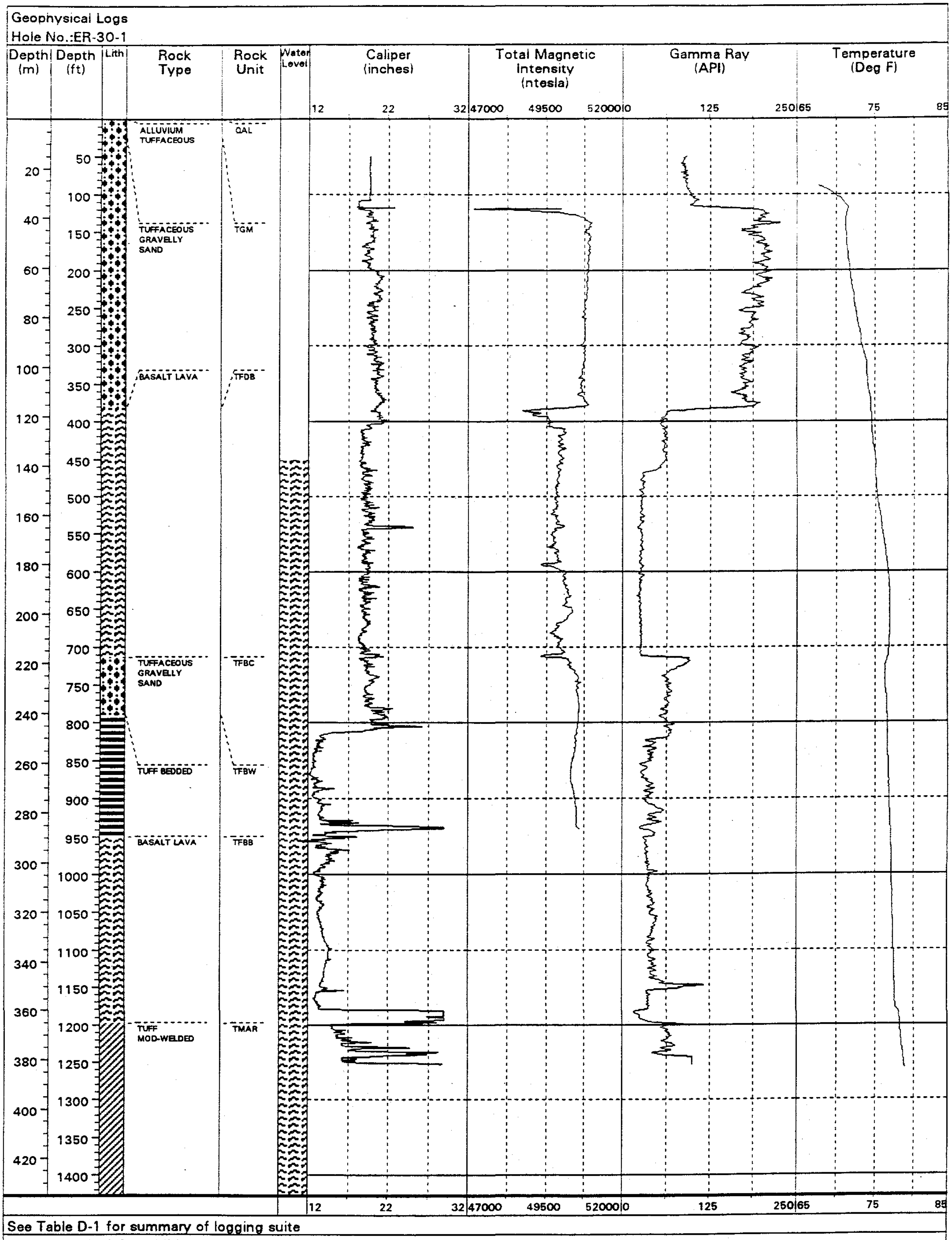
See Appendix C for additional lithologic and stratigraphic data


Geophysical Logs
Hole No.:ER-30-1
Depth (m)
Depth (ft)
Lith
Rock Type
Rock Unit
Water Level
Caliper (inches)
Density (g/cc)
Epithermal Neutron Porosity (API)
Acoustic (microsec/ft)
12 22 32
1.0 2.0 3.0
0 4000 8000
0 150 300
ALLUVIUM TUFFACEOUS
QAL
TUFFACEOUS GRAVELLY SAND
TGM
BASALT LAVA
TFDB
TUFFACEOUS GRAVELLY SAND
TFBC
TUFF BEDDED
TFBW
BASALT LAVA
TFBB
TUFF MOD-WELDED
TMAR
20 40 60 80 100 120 140 160 180 200 220 240 260 280 300 320 340 360 380 400 420
50 100 150 200 250 300 350 400 450 500 550 600 650 700 750 800 850 900 950 1000 1050 1100 1150 1200 1250 1300 1350 1400
See Table D-1 for summary of logging suite
See Appendix C for additional lithologic and stratigraphic data



See Table D-1 for summary of logging suite

See Appendix C for additional lithologic and stratigraphic data



See Table D-1 for summary of logging suite

See Appendix C for additional lithologic and stratigraphic data

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