

Nevada
Environmental
Restoration
Project

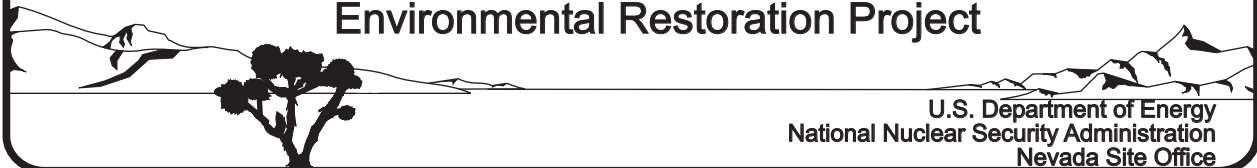


Completion Report for Well ER-12-3

Corrective Action Unit 99: Rainier Mesa - Shoshone Mountain

May 2006

Environmental Restoration Project



U.S. Department of Energy
National Nuclear Security Administration
Nevada Site Office

DISCLAIMER STATEMENT

Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise, does not necessarily constitute or imply its endorsement, recommendation, or favoring by the U.S. Government or any agency thereof or its contractors or subcontractors.

AVAILABILITY STATEMENT

Available to the public, in paper, from—

U.S. Department of Commerce
National Technical Information Service
5285 Port Royal Road
Springfield, VA 22161-0002
Telephone: 800.553.6847
Fax: 703.605.6900
E-mail: orders@ntis.gov
Online ordering: <http://www.ntis.gov/ordering.htm>

Available electronically at <http://www.osti.gov/bridge>.

Available for a processing fee to U.S. Department of Energy and its contractors, in paper, from—

U.S. Department of Energy
Office of Scientific and Technical Information
P.O. Box 62
Oak Ridge, TN 37831-0062
Telephone: 865.576.8401
Fax: 865.576.5728
E-mail: reports@adonis.osti.gov

Completion Report for Well ER-12-3

Corrective Action Unit 99:
Rainier Mesa - Shoshone Mountain, Nevada


Prepared for:
U.S. Department of Energy
National Nuclear Security Administration
Nevada Site Office
Las Vegas, Nevada

Prepared by:
Bechtel Nevada
Geotechnical Sciences
Las Vegas, NV

May 2006

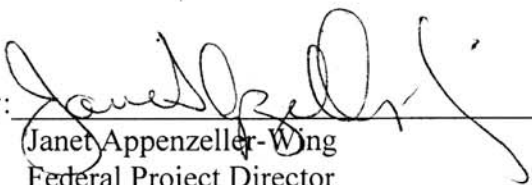
This page intentionally left blank.

COMPLETION REPORT FOR WELL ER-12-3
CORRECTIVE ACTION UNIT 99:
RAINIER MESA - SHOSHONE MOUNTAIN, NEVADA

Approved by: 

Wilhelm R. Wilborn
Federal Sub-Project Director
Underground Test Area Sub-Project

Date: 5/25/06

Approved by: 

Janet Appenzeller-Wing
Federal Project Director
Environmental Restoration Project

Date: 5/25/06

This page intentionally left blank.

Completion Report for Well ER-12-3
Corrective Action Unit 99: Rainier Mesa - Shoshone Mountain, Nevada
DOE/NV/11718--1182

ABSTRACT

Well ER-12-3 was drilled for the U.S. Department of Energy, National Nuclear Security Administration Nevada Site Office, in support of the Nevada Environmental Restoration Project at the Nevada Test Site, Nye County, Nevada. The well was drilled in March and April 2005 as part of a hydrogeologic investigation program for the Rainier Mesa-Shoshone Mountain Corrective Action Unit. The overall purpose of the well was to gather subsurface data to better characterize the hydrogeology of central Rainier Mesa, especially in the older Tertiary volcanic rocks and Paleozoic sedimentary rocks. The main 47.0-centimeter hole was drilled to a depth of 799.2 meters and cased with 33.97-centimeter casing to 743.1 meters. The hole diameter was then decreased to 31.1 centimeters, and the well was drilled to a total depth of 1,496.0 meters. The completion string consisted of 13.97-centimeter stainless steel casing, with two slotted intervals open to the lower carbonate aquifer, suspended from 19.37-centimeter carbon steel casing. A piezometer string was installed outside the 33.97-centimeter casing to a depth of 467.1 meters to monitor a zone of perched water within the Tertiary volcanic section.

Data gathered during and shortly after hole construction include composite drill cuttings samples collected every 3 meters (extra cuttings samples were collected from the Paleozoic rocks for paleontological analyses), sidewall core samples from 35 depths, various geophysical logs, and water level measurements. These data indicate that the well penetrated 674.2 meters of Tertiary volcanic rocks and 821.7 meters of Paleozoic dolomite and limestone. Forty-nine days after the well was completed, but prior to well development and testing, the water level inside the main hole was tagged at the depth of 949.1 meters, and the water level inside the piezometer string was tagged at 379.9 meters.

This page intentionally left blank.

Table of Contents

Abstract	v
List of Figures	ix
List of Tables	x
List of Acronyms and Abbreviations	xi
1.0 Introduction	1-1
1.1 Project Description	1-1
1.2 Objectives	1-6
1.3 Project Summary	1-7
1.4 Project Director	1-8
2.0 Drilling Summary	2-1
2.1 Introduction	2-1
2.2 Drilling History	2-1
2.3 Drilling Problems	2-10
2.4 Fluid Management	2-10
3.0 Geologic Data Collection	3-1
3.1 Introduction	3-1
3.2 Collection of Drill Cuttings	3-1
3.3 Sidewall Core Samples	3-2
3.4 Sample Analyses	3-2
3.5 Geophysical Log Data	3-2
4.0 Geology and Hydrogeology	4-1
4.1 Introduction	4-1
4.2 Geology	4-1
4.2.1 Geologic Setting	4-1
4.2.2 Stratigraphy and Lithology	4-5
4.2.3 Alteration	4-13
4.3 Predicted and Actual Geology	4-13
4.4 Hydrogeology	4-15

Table of Contents (Continued)

5.0 Hydrology	5-1
5.1 Preliminary Water-Level Information	5-1
5.2 Water Production	5-1
5.3 Preliminary Flow Meter Data	5-2
5.4 Preliminary Groundwater Characterization Samples	5-2
6.0 Precompletion and Open-Hole Development	6-1
7.0 Well Completion	7-1
7.1 Introduction	7-1
7.2 Well Completion Design	7-1
7.2.1 Proposed Completion Design	7-1
7.2.2 As-Built Completion Design	7-5
7.2.3 Rationale for Differences between Planned and Actual Well Design	7-5
7.3 Well Completion Method	7-6
8.0 Planned and Actual Costs and Scheduling	8-1
9.0 Summary, Recommendations, and Lessons Learned	9-1
9.1 Summary	9-1
9.2 Recommendations	9-1
9.3 Lessons Learned	9-2
10.0 References	10-1
Appendix A - Drilling Data	
A-1 Drilling Parameter Log for Well ER-12-3	
A-2 Tubing and Casing Data for Well ER-12-3	
A-3 Well ER-12-3 Drilling Fluids and Cement Composition	
Appendix B - Well ER-12-3 Fluid Management Data	
Appendix C - Detailed Lithologic Log for Well ER-12-3	
Appendix D - Geophysical Logs Run in Well ER-12-3	
Distribution List	

List of Figures

1-1	Reference Map Showing Location of Well ER-12-3	1-3
2-1	Drill Site Configuration for Well ER-12-3	2-2
2-2	Well ER-12-3 Drilling and Completion History	2-3
4-1	Surface Geologic Map of the Well ER-12-3 Site	4-3
4-2	Geology and Hydrogeology for Well ER-12-3	4-7
4-3	Southwest-Northeast Geologic Cross Section A-A' through Well ER-12-3	4-9
4-4	South-North Geologic Cross Section B-B' through Well ER-12-3	4-10
4-5	Predicted and Actual Stratigraphy at Well ER-12-3	4-14
4-6	Southwest-Northeast Hydrogeologic Cross Section C-C' through Well ER-12-3 ...	4-17
7-1	As-Built Completion Schematic for Well ER-12-3	7-2
7-2	Wellhead Diagram for Well ER-12-3	7-3
8-1	Planned and Actual Construction Progress for Well ER-12-3	8-2
8-2	Planned and Actual Cost of Constructing Well ER-12-3	8-3

List of Tables

1-1	Well ER-12-3 Site Data Summary	1-5
2-1	Abridged Drill Hole Statistics for Well ER-12-3	2-7
3-1	Sidewall Samples from Well ER-12-3	3-3
3-2	Status of Rock Sample Analyses for Well ER-12-3	3-5
3-3	Well ER-12-3 Geophysical Log Summary	3-6
7-1	Well ER-12-3 Completion String Construction Summary	7-4
A-2	Tubing and Casing Data for Well ER-12-3	A-2-1
A-3-1	Drilling Fluids Used in Well ER-12-3	A-3-1
A-3-2	Well ER-12-3 Cement Composition	A-3-1
B-1	Well ER-12-3 Fluid Disposition Reporting Form	B-1
B-2	Preliminary Analytical Results for Fluid Management Samples from Well ER-12-3	B-2
D-1	Well ER-12-3 Geophysical Logs Presented	D-1

List of Acronyms and Abbreviations

AC	analysis complete
BHA	bottom-hole assembly
BN	Bechtel Nevada
°C	Celsius
CAU	Corrective Action Unit
cm	centimeter(s)
DC	drill cuttings
DOE/NV	U.S. Department of Energy, Nevada Operations Office
DRI	Desert Research Institute
E	east
EC	electrical conductivity
°F	Fahrenheit
FAWP	Field Activity Work Plan
FMP	Fluid Management Plan
ft	foot (feet)
FY	fiscal year
gpm	gallons per minute
HES	Halliburton Energy Services
HSU	hydrostratigraphic unit
in.	inch(es)
IT	IT Corporation
L	liter(s)
LANL	Los Alamos National Laboratory
LCA	lower carbonate aquifer
lpm	liters per minute
m	meter(s)
Ma	million years (ago)
N	north
NAD	North American Datum
NARA	National Archives and Records Administration
NNSA/NSO	U.S. Department of Energy, National Nuclear Security Administration Nevada Site Office
NP	analysis not planned
NTS	Nevada Test Site
pCi/L	picocuries per liter

List of Acronyms and Abbreviations *(continued)*

PG	percussion-gun sidewall coring tool
RS	rotary sidewall coring tool
SNJV	Stoller Navarro Joint Venture
TCU	tuff confining unit
TD	total depth
UGTA	Underground Test Area
UDI	United Drilling, Incorporated
USGS	U.S. Geological Survey
XRD	x-ray diffraction
XRF	x-ray fluorescence

1.0 Introduction

1.1 Project Description

Well ER-12-3 was drilled for the U.S. Department of Energy, National Nuclear Security Administration Nevada Site Office (NNSA/NSO) in support of the Nevada Environmental Restoration Project at the Nevada Test Site (NTS), Nye County, Nevada. Well ER-12-3 was the first of three wells drilled in Fiscal Year (FY) 2005 as part of the hydrogeologic investigation well drilling program for the Rainier Mesa-Shoshone Mountain Corrective Action Unit (CAU). The Rainier Mesa-Shoshone Mountain CAU and associated well drilling program are part of the NNSA/NSO Environmental Restoration Project's Underground Test Area (UGTA) sub-project at the NTS. The goals of the UGTA sub-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 sub-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 quality, migration pathways, and migration rates.

Well ER-12-3 is located near the center of Rainier Mesa, in Area 12 of the NTS, at an elevation of 2,252.7 meters (m) (7,390.8 feet [ft]) (Figure 1-1). The surface is relatively flat-lying in the vicinity of Well ER-12-3, with surface drainage to the southwest. The Nevada State (central zone) plane coordinates (North American Datum [NAD] 1983 [National Archives and Records Administration (NARA), 1989]) at the wellhead are North (N) 6,271,358.5 and East (E) 540,097.2 m. Additional site data are listed in Table 1-1. The well provided information that will enhance the understanding of the hydrogeology of Rainier Mesa.

Stoller Navarro Joint Venture (SNJV), was the principal environmental contractor for the project, and SNJV personnel collected geologic and hydrologic data during drilling. The drilling company was United Drilling, Incorporated (UDI), a subcontractor to Bechtel Nevada (BN). Site supervision, 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-95NV31874, and in BN Field Activity Work Plan (FAWP) number D-002-001.05 (BN, 2005). The UGTA Technical Working Group, a committee of scientists and engineers comprising NNSA/NSO, Lawrence Livermore National Laboratory,

This page intentionally left blank.

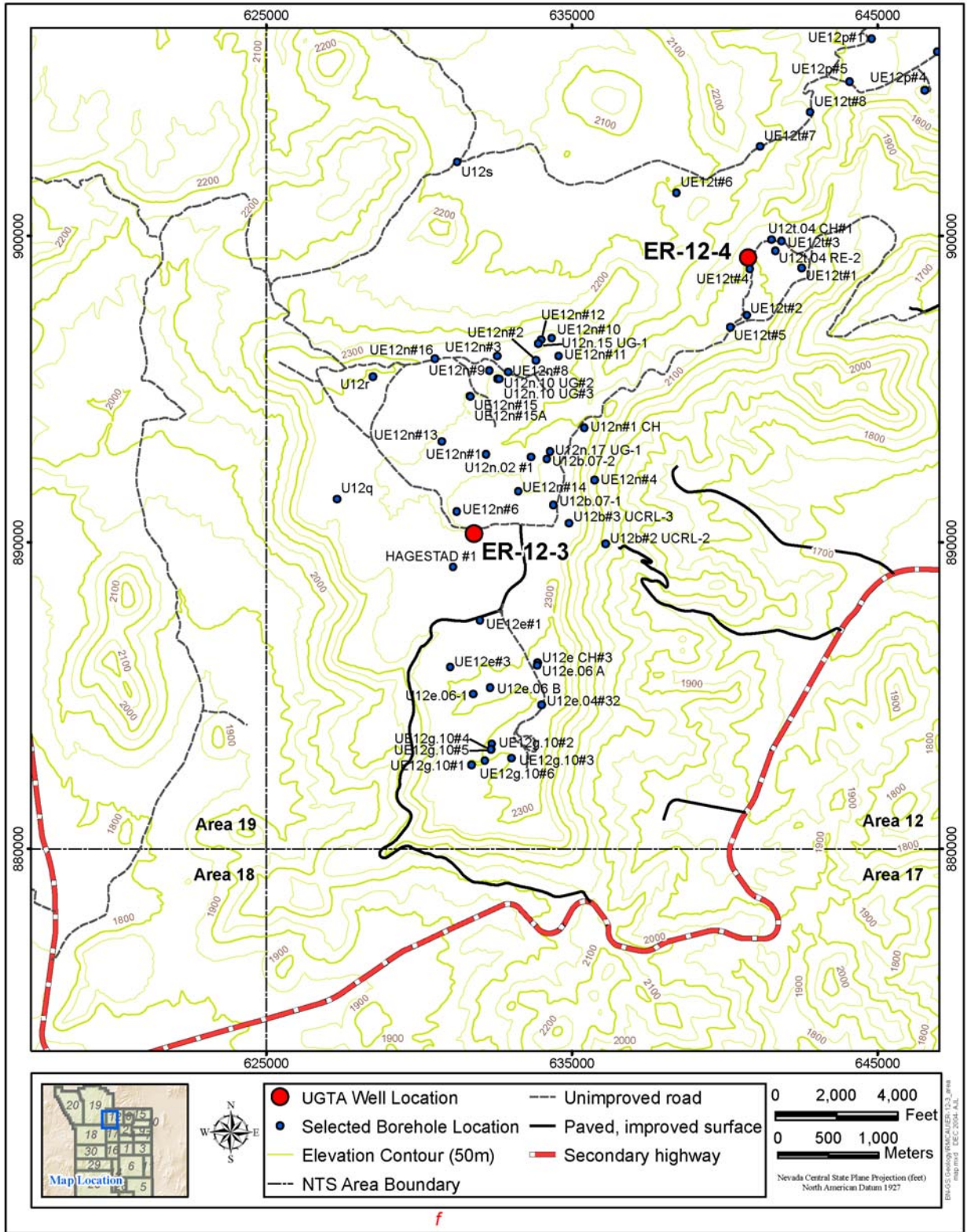


Figure 1-1
Reference Map Showing Location of Well ER-12-3

This page intentionally left blank.

**Table 1-1
Well ER-12-3 Site Data Summary**

Well Designation	ER-12-3
Site Coordinates ^a	Nevada State Plane (central zone) (NAD 83): N 6,271,358.5 m (N 20,575,282.0 ft) E 540,097.2 m (E 1,771,968.8 ft) Nevada State Plane (central zone) (NAD 27): N 890,278.7 ft E 631,811.0 ft Universal Transverse Mercator (Zone 11)(NAD 83): N 4,116,789.7 m E 569,668.4 m
Surface Elevation ^{a, b}	2,252.7 m (7,390.8 ft)
Drilled Depth	1,496.0 m (4,908 ft) on April 23, 2005
Fluid-Level Depth ^c	949.1 m (3,113.7 ft)
Fluid-Level Elevation	1,301.90 m (4,271.33 ft)

- a Measurement made by BN Survey. NAD 1983 (NARA, 1989); NAD 1927 (U.S. Coast and Geodetic Survey, 1927).
- b Elevation at top of construction pad. 1929 National Geodetic Vertical Datum (NARA, 1973).
- c Measured by SNJV in completion casing isolated within Paleozoic rocks on June 11, 2005, prior to well development.

Los Alamos National Laboratory (LANL), and contractor personnel, provided additional technical advice during drilling, design, and construction of the well. See *Rainier Mesa-Shoshone Mountain Hydrogeologic Investigation Wells Drilling and Completion Criteria* (SNJV, 2005a) for descriptions of the general plan and goals of the Rainier Mesa-Shoshone Mountain drilling initiative 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), Revision 3 (U.S. Department of Energy, Nevada Operations Office [DOE/NV], 2002a), an attachment to the UGTA Waste Management Plan (DOE/NV, 2002b). Estimates of expected production of fluid and drill cuttings for the Rainier Mesa-Shoshone Mountain holes are given in Appendix D of the drilling and completion criteria document for the drilling project (SNJV, 2005a), along with sampling requirements and contingency plans for management of any hazardous waste produced. All activities were conducted according to the BN FAWP number 002-001.05 (BN, 2005) and the UGTA Project Health and Safety Plan (BN, 2004).

This report presents construction data and summarizes scientific data gathered during drilling of Well ER-12-3. Some of the information in this report is preliminary and unprocessed, but is being released with the drilling and completion data for convenient reference. A well data report prepared by SNJV (SNJV, 2005b) contains additional information on fluid management, waste management, and environmental compliance. Updated geologic information for this area (including any changes in the geologic interpretation) will be compiled in the data documentation package for the Rainier Mesa-Shoshone Mountain hydrostratigraphic framework model to be prepared by BN. Well development, aquifer testing, and groundwater analytical sampling are outside the scope of this report; information on these activities will be compiled and disseminated separately, as it is acquired.

1.2 Objectives

The overall purpose of constructing Well ER-12-3 is to obtain information that will help characterize the hydrogeology of central Rainier Mesa. The primary scientific objectives for the well, as discussed in the drilling criteria document (SNJV, 2005a), include the following:

- Obtain geologic samples and geophysical data that will aid in defining hydrostratigraphic units (HSUs) and characterizing any geologic structures encountered. This geologic information will be used to support the development of an UGTA CAU-specific hydrostratigraphic framework model and reduce uncertainties, especially regarding:
 - extent and thickness of the upper thrust plate of the Belted Range thrust fault
 - character of structural features such as the Belted Range thrust fault and the Rainier Mesa syncline
- Obtain detailed water-level data to determine the regional water level and investigate potential local groundwater flow toward or along the Rainier Mesa syncline.
- Investigate the possibility of perched water zones above the regional water level.
- Obtain aqueous geochemistry samples from the lower carbonate aquifer-3 (LCA3) to establish water chemistry and age.
- Obtain geologic samples for detailed mineralogic analysis to help define the vertical distribution of reactive minerals such as clays, zeolites, and iron oxides in the deep Tertiary volcanic section.

See discussions in Section 4.0 and 5.0 for more information on the objectives mentioned above.

Some of these objectives were based on the assumption that Well ER-12-3 would penetrate Precambrian quartzite in the upper plate of the Belted Range thrust fault. As discussed in following sections, the well reached total depth (TD) in Paleozoic carbonate rocks, never penetrating the thrust fault. Therefore, some of the scientific objectives were not met as anticipated. Also, some other objectives will not be met until additional work, outside the scope of this report, is completed, including installing a pump and conducting hydraulic testing.

1.3 Project Summary

This section summarizes Well ER-12-3 construction operations; the details are provided in Sections 2.0 through 8.0 of this report.

The surface conductor hole was started by drilling a 31.1-centimeter (cm) (12¼-inch [in.]) pilot hole to a depth of 18.3 m (60 ft) using an air-hammer. Ten blast holes were drilled in two concentric rings around the pilot hole, and explosives were detonated in seven of the blast holes. The pilot hole was then opened to a diameter of 121.9 cm (48 in.) by augering through the rubble to a depth of 16.8 m (55 ft) and installing a string of 30-in. conductor casing to 16.5 m (54 ft).

Drilling of the main hole with a 20-in. hammer bit, using a foam/polymer drill fluid in conventional circulation, began on March 26, 2005. At a depth of 78.0 m (256 ft) the 20-in. hammer bit was replaced with an 18½-in. rotary bit. A suitable place to set the surface casing was reached at 799.2 m (2,622 ft), and drilling was suspended as planned for geophysical logging prior to installing the casing. A string of 13¾-in. casing was set at 743.1 m (2,438.0 ft) on April 8, 2005. After the bottom of the casing was cemented, a 2¾-in. diameter piezometer string was installed between the casing and the borehole wall to provide access to water-producing horizons noted during drilling at 419.7 and 468.5 m (1,377 and 1,537 ft). The bottom of the piezometer string was placed at 467.1 m (1,532.5 ft); the lowermost 36.0 m (118 ft) of the string is slotted. The remainder of the hole was drilled with a 12¼-in. bit using air-foam to a TD of 1,496.0 m (4,908 ft), which was reached on April 23, 2005. Geophysical logging was conducted before the completion string was installed.

Tritium levels measured in the drilling fluid remained at or below background levels throughout most of the drilling operations, ranging from 0 to 2,982 picoCuries per liter (pCi/L), as measured by field equipment.

Composite drill cuttings were collected every 3 m (10 ft) from the surface to TD, and 35 sidewall core samples were taken at various depths between 121.9 and 1,453.9 m (400 and 4,770 ft).

Open-hole geophysical logging of the well was conducted to help verify the geology and characterize the hydrologic properties of the rocks; some logs also aided in the construction of the well by indicating borehole volume and condition. The well penetrated 674.2 m (2,212 ft) of Tertiary volcanic rocks and 821.7 m (2,696 ft) of Paleozoic dolomite and limestone.

The well was completed with 5½-in. stainless-steel casing with two slotted intervals, open to the lower carbonate aquifer (LCA), suspended from 7⅝-in. carbon-steel casing. The completion casing was landed at 1,487.4 m (4,880.0 ft) with slotted intervals between 1,094.5 and 1,160.0 m (3,591.0 and 3,805.8 ft) and between 1,277.6 and 1,473.6 m (4,191.6 and 4,834.7 ft).

1.4 Project Director

Inquiries concerning Well ER-12-3 should be directed to the UGTA Federal Project Director at:

U.S. Department of Energy
National Nuclear Security Administration
Nevada Site Office
Environmental Restoration Project
Post Office Box 98518
Las Vegas, Nevada 89193-8518

2.0 Drilling Summary

2.1 Introduction

This section contains detailed descriptions of the drilling process and fluid management issues. The general drilling requirements for all FY 2005 Rainier Mesa-Shoshone Mountain wells were provided in *Rainier Mesa-Shoshone Mountain Hydrogeologic Investigation Wells Drilling and Completion Criteria* (SNJV, 2005a). Specific requirements for Well ER-12-3 were outlined in FAWP number 002-001.05 (BN, 2005), and amended as described in Bangerter (2005).

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-12-3. A summary of drilling statistics for the well is given in Table 2-1.

The following information was compiled primarily from BN daily drilling reports.

2.2 Drilling History

Field operations at Well ER-12-3 began on January 18, 2005, when BN drillers, using the CP-750 rig, drilled a 31.1-cm (12.25-in.) pilot hole to 18.3 m (60 ft) using an air-hammer. The CP-750 rig was then used to drill ten 11.4-cm (4.5-in.) blast holes in two concentric rings around the pilot hole. Three blast holes were deemed unuseable. One of the inner ring holes was abandoned at a depth of 9.1 m (30 ft), because it was found to be communicating with the pilot hole. One of the outer ring holes was intersected by its corresponding inner ring hole. The remaining seven useable blast holes, ranging in depth from 18.3 to 18.9 m (60 to 62 ft), were lined with 5.1-cm (2-in.) polyvinyl chloride tubing. On February 1, 2005, 204 kilograms (450 pounds) of ammonium nitrate and 17 sticks of dynamite were detonated in the seven blast holes. The CP-750 rig was then used to drill four 31.1-cm (12.25-in.) diameter anchor holes to 3.0 m (10 ft). Starting February 2, 2005, the pilot hole was opened to a diameter of 121.9-cm (48-in.) to a depth of 16.8 m (55 ft) by using Auger Rig 85134 to drill through the rubble. A string of 30-in. conductor casing was set at the depth of 16.5 m (54 ft). The bottom of the conductor casing was cemented inside to 15.1 m (49.6 ft) on February 9, 2005, and the annulus was cemented from the bottom of the casing to ground level on February 10, 2005.

There was no activity at the well site until the UDI crews arrived and rigged up the Wilson Mogul 42B between March 12 and 25, 2005. The top of cement inside the 30-in. casing was tagged at 16.2 m (53 ft), indicating that the cement surface had dropped since its emplacement on February 9, 2005. Drilling resumed through the cement at the bottom of the 30-in. casing with a center-punch assembly consisting of an 20-in. rotary bit mounted 2.56 m (8.4 ft) below a

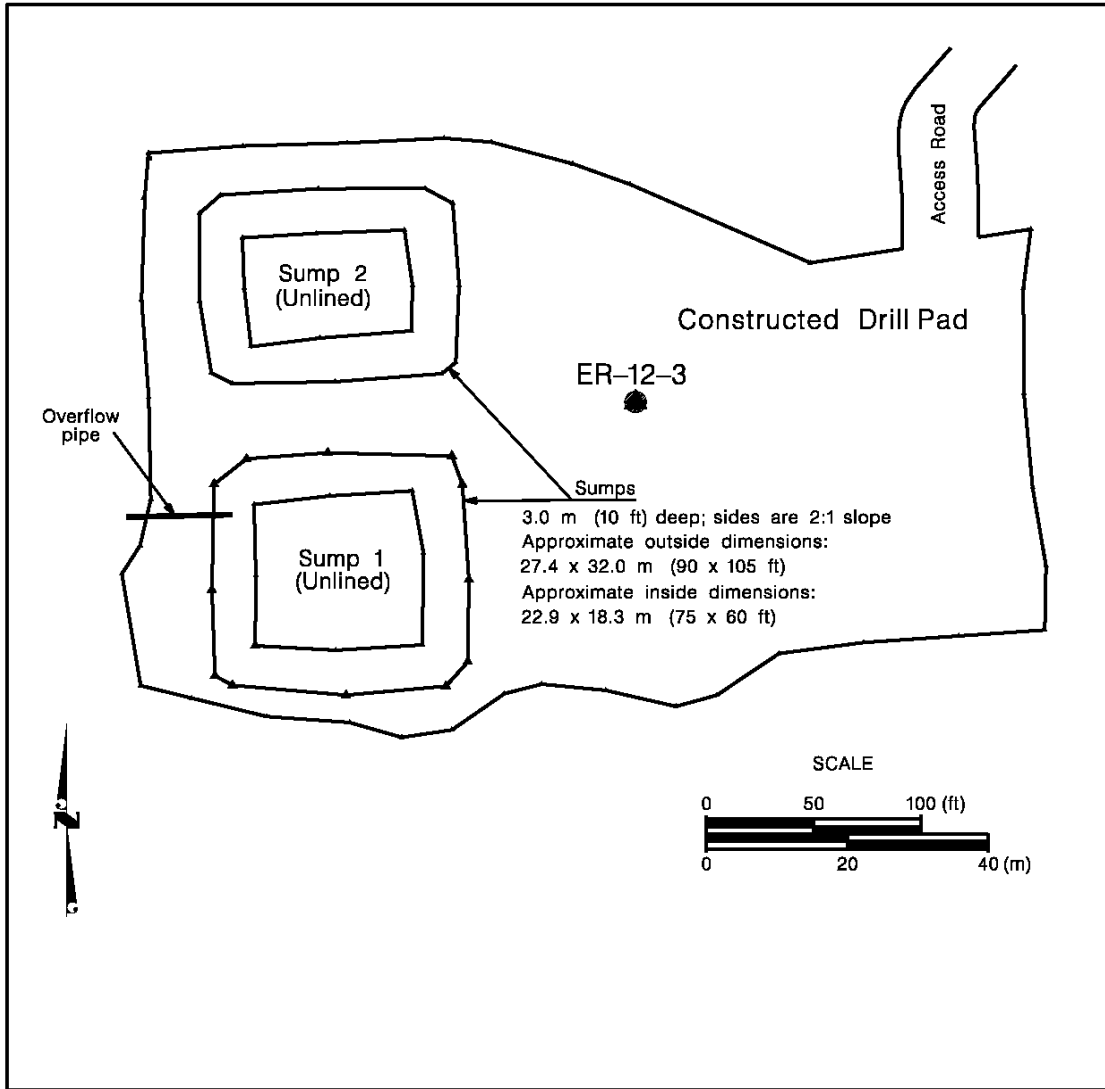


Figure 2-1
Drill Site Configuration for Well ER-12-3

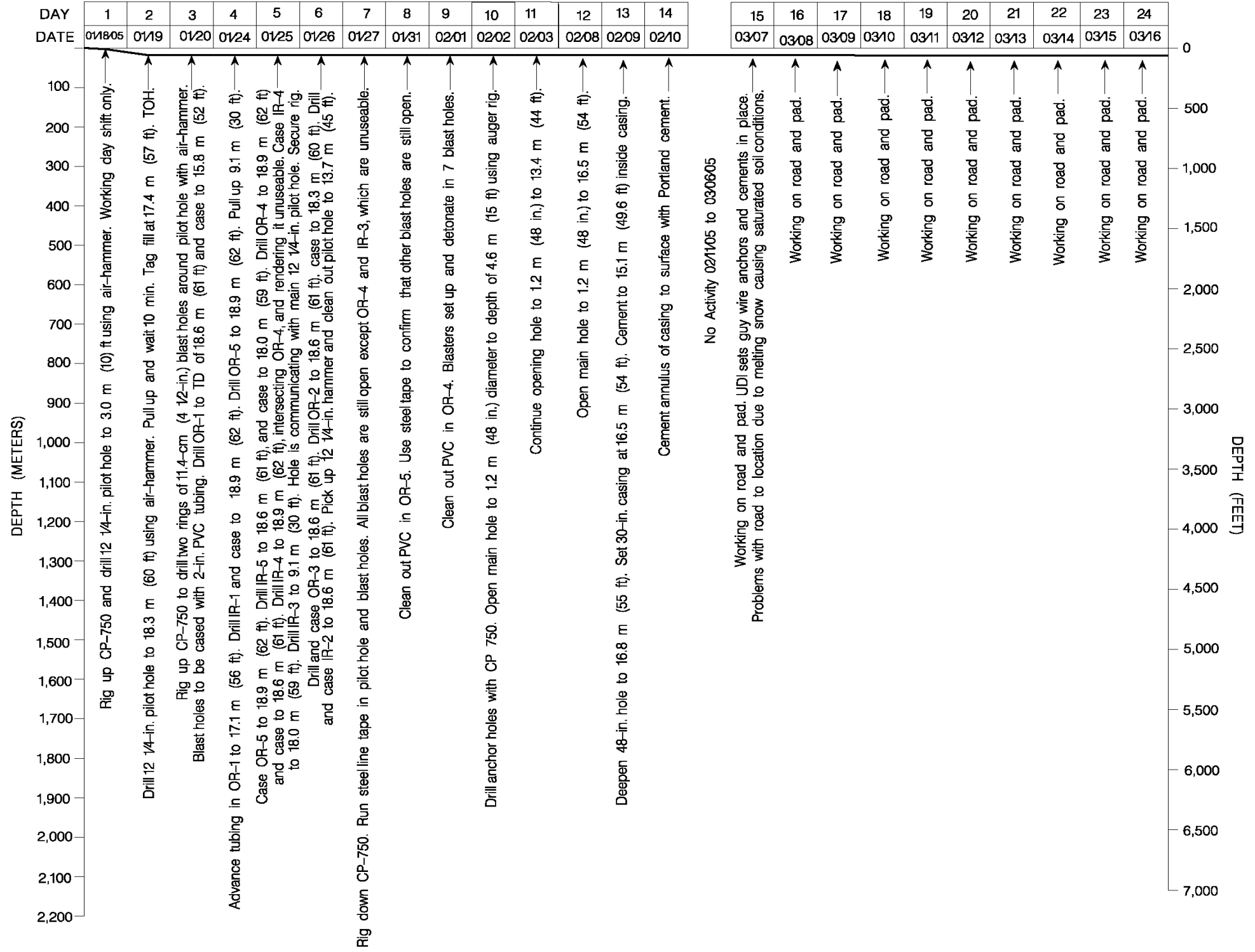
WELL ER-12-3 SUMMARY

Activity	Date
Begin drilling pilot hole:	01/18/2005
Conductor hole completed and 30-in. casing set at 16.5 m (54 ft):	02/09/2005
Begin drilling 20-in. surface hole:	03/26/2005
Begin drilling 18 1/2-in. hole:	03/29/2005
13 3/8-in. intermediate casing set at 743.1 m (2,438.0 ft):	04/08/2005
Begin drilling 12 1/4-in. hole:	04/11/2005
Reach total drilled depth of 1,496.0 m (4,908 ft):	04/23/2005

LEGEND

bbl	barrel(s)
BHA	bottom hole assembly
bgs	below ground surface
DRI	Desert Research Institute
ft	foot (feet)
HES	Halliburton Energy Services
hr	hour(s)
in.	inch(es)
m	meter(s)
SLM	steel line measurement
SNJV	Stoller Navarro Joint Venture
SWC	sidewall core
TD	total depth
TIH	trip into hole
TOH	trip out of hole
UDI	United Drilling Inc.

**FIGURE 2-2
WELL ER-12-3
DRILLING AND COMPLETION
HISTORY
SHEET 1 OF 3**



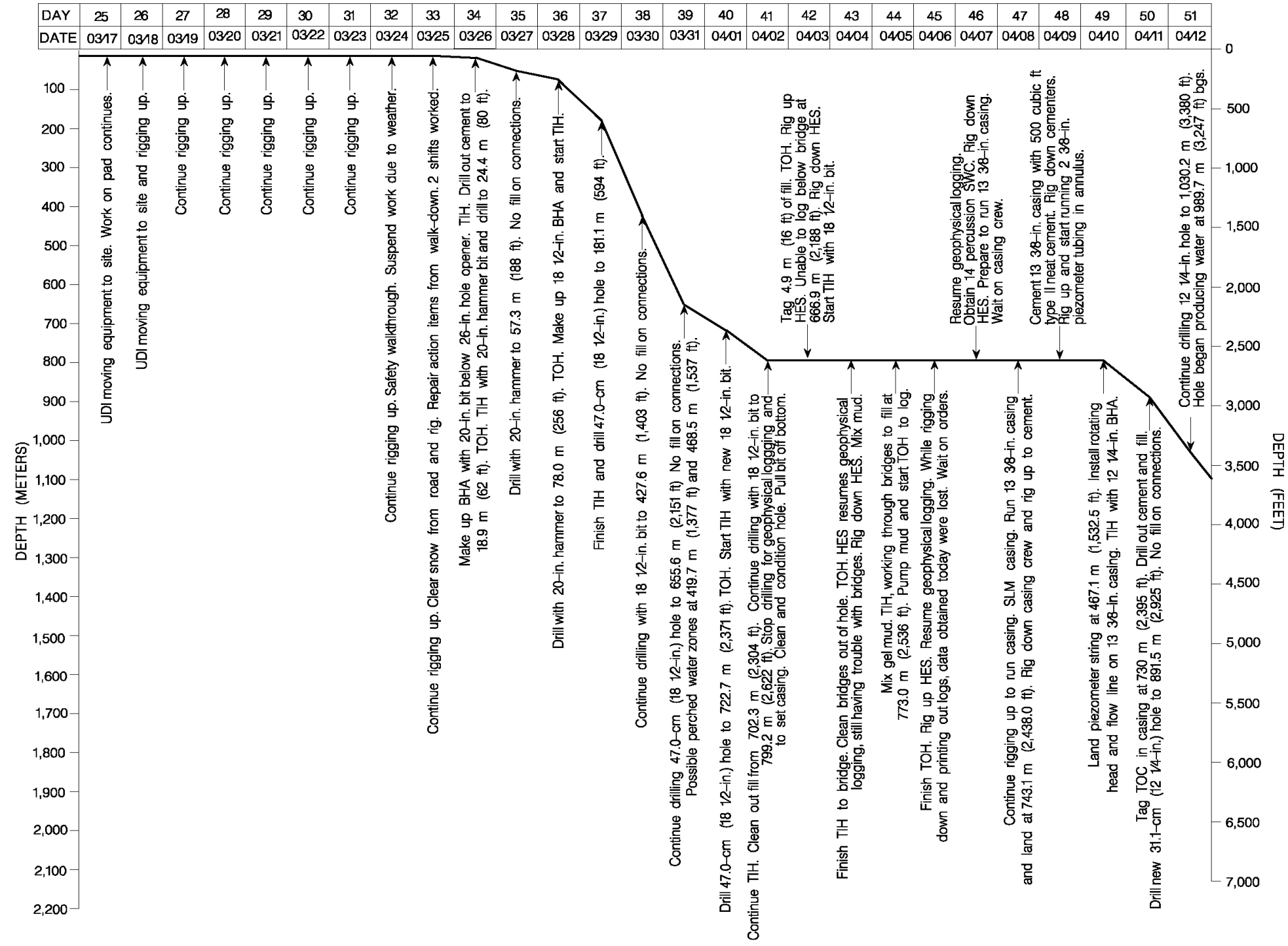
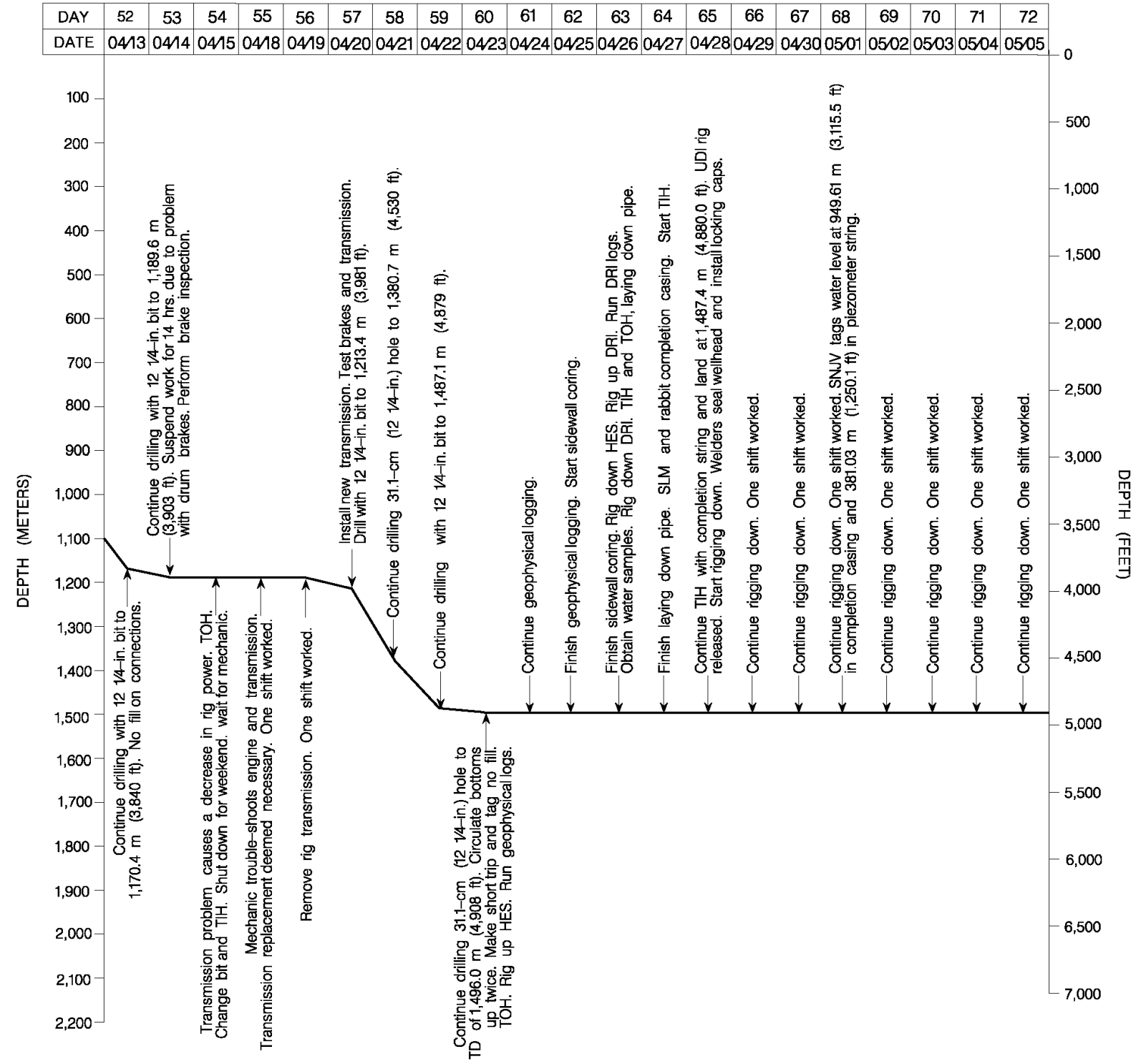


FIGURE 2-2
 WELL ER-12-3
 DRILLING AND COMPLETION
 HISTORY
 SHEET 2 OF 3

FIGURE 2-2
WELL ER-12-3
DRILLING AND COMPLETION
HISTORY
SHEET 3 OF 3



This page intentionally left blank.

**Table 2-1
Abridged Drill Hole Statistics for Well ER-12-3**

LOCATION DATA:	
Coordinates:	Nevada State Plane (central zone): NAD 83: N 6,271,358.5 m E 540,097.2 m NAD 27: N 890,278.7 ft E 631,811.0 ft Universal Transverse Mercator: NAD 83: N 4,116,789.7 m E 569,668.4 m
Surface Elevation ^a :	2,252.7 m (7,390.8 ft)
DRILLING DATA:	
Spud Date:	01/18/2005: Pilot hole drilling with CP-750 rig 03/26/2005: Main hole drilling with Wilson Mogul 42B rig
Total Depth (TD):	1,496.0 m (4,908 ft)
Date TD Reached:	04/23/2005
Date Well Completed :	04/28/2005
Hole Diameter:	121.9 cm (48 in.) from surface to 16.8 m (55 ft); 50.8 cm (20 in.) from 16.8 to 78.0 m (55 to 256 ft); 47.0 cm (18.5 in.) from 78.0 to 799.2 m (256 to 2,622 ft); 31.1 cm (12.25 in.) from 799.2 m (2,622 ft) to a TD of 1,496.0 m (4,908 ft).
Drilling Techniques:	Drill pilot hole and two rings of blast holes with air-hammer from surface to 18.3 m (60 ft), and blast through caprock; clean out with auger to 16.8 m (55 ft). Center-punch with 26-in. hole opener above 20-in. bit, using air-foam and polymer in direct circulation from top of cement at 16.2 m to 18.9 m (53 to 62 ft). Drill with 20-in. hammer bit using air-foam and polymer in direct circulation from 18.9 to 78.0 m (62 to 256 ft); rotary drill with 18½-in. tricone bit using air-foam and polymer in direct circulation from 78.0 to 799.2 m (256 to 2,622 ft); rotary drill with 12¼-in. tricone bit using air-foam and polymer in direct circulation from 799.2 m (2,622 ft) to TD of 1,496.0 m (4,908 ft).
CASING DATA:	30-in. conductor casing, surface to 16.5 m (54.0 ft); 13⅝-in. casing, surface to 743.1 m (2,438.0 ft).
WELL COMPLETION DATA:	
Completion string consists of 5½-in. stainless-steel casing with two slotted intervals, suspended from 7⅝-in. carbon-steel casing. The stainless-steel casing has an outside diameter of 13.97 cm (5.500 in.) and inside diameter of 12.82 cm (5.047 in.). The carbon-steel casing has an outside diameter of 19.37 cm (7.625 in.) and inside diameter of 17.70 cm (6.969-in.). A 2⅝-in. carbon-steel piezometer string was installed outside the 13⅝-in. intermediate casing. The piezometer tubing has an outside diameter of 6.03 cm (2.375 in.) and inside diameter of 5.07 cm (1.995 in.).	
Completion String Total Depth:	1,487.4 m (4,880.0 ft)
Depth of Slotted Sections:	1,094.5 to 1,160.0 m (3,591.0 to 3,805.8 ft) and 1,277.6 to 1,473.6 m (4,191.6 to 4,834.7 ft).
Gravel/Sand Pack:	None
Piezometer Total Depth:	467.1 m (1,532.5 ft)
Depth of Slotted Section:	431.2 to 467.1 m (1,414.5 to 1,532.5 ft)
Gravel/Sand Pack:	None
Top of fill:	1,494.4 m (4,903 ft) on 04/28/2005
Water Depth ^b :	949.1 m (3,113.7 ft) in the completion string 379.9 m (1,246.3 ft) in the piezometer
DRILLING CONTRACTOR:	United Drilling, Inc.
GEOPHYSICAL LOGS BY:	Halliburton Energy Services; Desert Research Institute
SURVEYING CONTRACTOR:	Bechtel Nevada

a Elevation of ground level at wellhead. 1929 National Geodetic Vertical Datum (NARA, 1973).

b Measured by Stoller Navarro Joint Venture on June 11, 2005, approximately 6 weeks after TD was reached, prior to well development (SNJV, 2005b).

26-in. hole opener, using air, water, soap and polymer (“polymer-foam”) in conventional circulation. When the 20-in. bit reached a depth of 18.9 m (62 ft), the hole opener was removed.

Drilling of the main 50.8-cm (20-in.) hole with a 20-in. hammer bit and polymer-foam began March 26, 2005. On March 28, 2005, at a depth of 78.0 m (256 ft), the hammer bit stopped working. The drillers removed the drill string and exchanged the bit for an 18½-in. rotary button bit. The new bottom-hole assembly (BHA) was lowered into the hole, and drilling continued uneventfully with little or no fill on connections. The first water production was noted by SNJV personnel on March 31, 2005, at a depth of 419.7 m (1,377 ft). Water was again noted at 468.5 m (1,537 ft). When the depth of 799.2 m (2,622 ft) was reached on April 2, 2005, drilling was stopped for geophysical logging and to run 13¾-in. casing. The drillers circulated the air-foam system to clean and condition the hole, pulled the drill string off the bottom, and waited about 30 minutes before lowering the drill string to 794.3 m (2,606 ft) and encountering fill. The drill string was removed from the hole, and Halliburton Energy Services (HES) rigged up for geophysical logging operations.

The loggers encountered a bridge of sloughed material at 666.9 m (2,188 ft) while lowering the tool into the hole. After making two logging runs up from the bridge to the bottom of the casing shoe, HES rigged down so drillers could clear the hole with the 18½-in bit. After the bit run, HES resumed logging operations, only to hit a bridge at 672.4 m (2,206 ft). The HES logging crew again rigged down, and drillers again worked the bit through bridges to fill at 773.0 m (2,536 ft). At this depth, 31,797 liters (200 barrels) of 61-viscosity gel mud was pumped into the hole. As the bit was removed from the hole, the drillers pumped 22,258 liters (140 barrels) of gel mud at the 701.0 m (2,300 ft) depth and checked for obstructions. A third attempt at logging was successful to a depth of 745.5 m (2,446 ft). As the HES crew were rigging down and printing logs, data from the last logging run were accidentally deleted. As the logging run was repeated, the bridge broke through and a depth of 753.8 m (2,473 ft) was reached. Fourteen percussion sidewall cores were obtained between the depths of 121.9 and 730.0 m (400 and 2,395 ft).

After logging was completed, a string of 13¾-in. casing was run into the hole to a depth of 743.1 m (2,438.0 ft). The bottom of the casing was cemented with 14.2 cubic meters (500 cubic feet) of Type II neat cement on April 9, 2005.

A piezometer string consisting of 2¾-in. carbon-steel tubing was lowered into the hole between the borehole wall and the 13¾-in. casing to provide access to water-producing horizons noted

during drilling at 419.7 and 468.5 m (1,377 and 1,537 ft). The bottom of the piezometer string was placed at 467.1 m (1,532.5 ft), with slotted tubing from 431.1 m (1,414.5 ft) to the bottom. No stemming was placed around the piezometer string.

After installation of the casing and piezometer string, a 12¼-in. BHA was lowered into the hole to drill out the cement and clean out the hole to 799.2 m (2,622 ft). The top of cement inside the 13⅜-in. casing was tagged at 730.0 m (2,395 ft), and the cement was drilled out to 745.8 m (2,447 ft), 2.7 m (9 ft) below the cementing shoe. Below this depth the bit slid down to the top of fill at 794.9 m (2,608 ft), with the exception of drilling through one bridge at 766.9 to 767.2 m (2,516 to 2,517 ft). Fill material was encountered at 794.9 m (2,608 ft), and drilling of the 31.1-cm (12.25-in.) hole in rock started at 799.2 m (2,622 ft), on April 11, 2005.

Drilling with the 12¼-in. bit and foam/polymer drill fluid continued smoothly, with no fill on connections, until April 14, 2005, when drillers began to experience problems with the rig's drum brakes and transmission at a depth of 1,189.6 m (3,903 ft). The drillers removed the BHA from the hole, replaced it, and waited for mechanical repairs. Drilling was suspended for 5½ days while the rig transmission was replaced and brakes were inspected and tested.

Drilling resumed on April 20, 2005, and continued uneventfully, using a foam/polymer mix, until the TD of 1,496.0 m (4,908 ft) was reached on April 23, 2005. The hole was cleaned and conditioned by circulating the drilling fluid for about two hours. The drillers pulled four stands of drill pipe up off the bottom of the hole, and then lowered them back in to check for fill. No fill was detected, and the drill string was removed from the hole. Logging operations were conducted with no problems by HES on April 23, 24, and 25, 2005. Density logs detected the top of cement outside of the 13⅜-in. casing at 637.6 m (2,210 ft). Twenty-one rotary sidewall cores were obtained on April 25 and 26, 2005.

A completion string with two slotted intervals was run into the hole on April 28, 2005, landed at 1,487.4 m (4,880.0 ft). The slotted intervals were left unstemmed and open to the LCA. The drillers rigged down the drilling equipment and moved it to the Well ER-12-4 site between April 28 and May 5, 2005, working one shift a day.

A standard gyroscopic survey was not run in the borehole, but the inclination of the borehole was determined from two different HES Electric Micro Imager log runs. The borehole deviation reported here is from Run 2, made on April 23, 2005, in the interval 568.1 to 1,499.0 m (1,864 to 4,918 ft), which is a longer interval than measured in Run 3. Within this interval the

borehole drifted approximately 153.6 m (504 ft) to the north-northeast (bearing of 9.78 degrees). No abrupt changes in the borehole orientation (“doglegs”) are discernable. At the lowest logged depth of 1,499.1 m (4,918.3 ft) the true vertical depth is calculated to be 1,477.1 m (4,846.7 ft).

A graphical depiction of drilling parameters including penetration rate, rotary 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-12-3 are listed in Appendix A-3.

2.3 Drilling Problems

Although borehole sloughing was not a problem during drilling, problems were caused by bridges and fill that obstructed the borehole during the first logging run. It was necessary to stop logging and run the bit in the hole twice to clean it out. The most significant delays were caused by equipment failures on the drill rig.

2.4 Fluid Management

Drilling effluent was monitored according to the methods prescribed in the UGTA FMP (DOE/NV, 2002) and the associated state-approved, well-specific, fluid management strategy letter (Appenzeller-Wing, 2005). The foam/polymer drill 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. Bentonite mud drill fluid was also used during cleaning of the hole for the first logging run. Water used to prepare drilling fluids came from Water Well 8, located in Area 18. Lithium bromide was added to the drill fluid as a tracer to provide a means of estimating groundwater production. The rate of water inflow was estimated from the dilution of the tracer in the drill fluid returns.

To manage the anticipated water production, two sumps were constructed prior to drilling (Figure 2-1). No contaminants were expected during drilling at this site, so neither sump was lined. Samples of drilling effluent were collected hourly and analyzed on site by BN Radiation Operations personnel for the presence of tritium. As detailed in the SNJV data report (SNJV, 2005b) the onsite monitoring results indicate that tritium levels measured in the drilling fluid remained at or below background levels (as determined by field instruments) throughout most of the drilling operations, ranging from 0 to 2,982 pCi/L. Anomalously high concentrations (up to 46,825.8 pCi/L) determined for the first four samples, taken at depths between 23.5 and 28.3 m (77 and 93 ft), were found to have been caused by previously contaminated filtration equipment. An anomalous value of 126,368.9 pCi/L, obtained from a sample depth of 384.0 m

(1,260 ft), was unsupported by any data from nearby samples, and was assumed to be erroneous. Drilling fluids generated at Well ER-12-3 were not analyzed for lead, according to the approved Well ER-12-3 Fluid Management Strategy (Appenzeller-Wing, 2005). Sump #1 had an overflow pipe, from which accumulated drilling effluent and snowmelt were briefly allowed to discharge to the ground surface.

Samples of drilling fluid were collected from the sumps at Well ER-12-3 for water quality analyses if necessary during drilling operations. These samples were archived, but were never tested. A final sample was collected and analyzed from sump #1 on April 27, 2005, after well completion.

All fluid quality objectives were met, as shown on the fluid management reporting form dated September 29, 2005 (Appendix B). The form lists volumes of solids (drill cuttings) and fluids produced during well-construction operations (vadose- and saturated-zone drilling only; 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.

This page intentionally left blank.

3.0 Geologic Data Collection

3.1 Introduction

This section describes the sources of geologic data obtained from Well ER-12-3 and the methods of data collection. Improving the understanding of the subsurface structure, stratigraphy, and hydrogeology in the northwestern portion of Yucca Flat was among the primary objectives of Well ER-12-3, so the proper collection of geologic and hydrogeologic data from the borehole was considered fundamental to successful completion of the project.

Geologic data collected at Well ER-12-3 consist of drill cuttings, sidewall core samples, and geophysical logs. Data collection, sampling, transfer, and documentation activities were performed according to applicable contractor procedures, as listed in SNJV (2005a).

3.2 Collection of Drill Cuttings

Composite drill cuttings were collected from Well ER-12-3 at 3-m (10-ft) intervals as drilling progressed from the depth of 6.1 m (20 ft) to the TD of the well at 1,496.0 m (4,908 ft). Duplicate cuttings samples were collected by BN geologists during pilot hole drilling, to the depth of 18.3 m (60 ft). Below that depth SNJV personnel collected triplicate samples, each consisting of approximately 550 cubic centimeters of material, from 484 intervals. These samples are stored under environmentally controlled, secure conditions at the U.S. Geological Survey (USGS) Geologic Data Center and Core Library in Mercury, Nevada. One of each triplicate sample set 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 according to standard USGS Core Library procedures. The washed set was used by BN to construct the detailed lithologic log presented in Appendix C. The SNJV Field Representative collected an additional two sets of reference drill cuttings 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 SNJV. The other set is held by SNJV for future petrographic, mineralogic, and chemical analyses at LANL, if needed. In addition, 3.8 liters (1 gallon) of composite drill cuttings samples were collected at 15.2-m (50-ft) intervals while drilling the pre-Tertiary section. These samples were collected for biostratigraphic analysis. Samples not sent for analysis are stored at the USGS Geologic Data Center and Core Library in Mercury, Nevada.

3.3 Sidewall Core Samples

Sidewall core samples were collected from Well ER-12-3 to verify the stratigraphy and lithology at selected locations. Sample locations were selected by the SNJV Field Representative on the basis of field lithologic logs, with consideration of borehole conditions determined from caliper logs. The HES crew used a percussion gun tool to collect core samples between the depths of 121.9 and 730.0 m (400 and 2,395 ft). A total of 24 sample depths were attempted, with 14 cores recovered. HES used a rotary sidewall coring tool to collect sidewall cores from 865.6 to 1,453.9 m (2,840 to 4,770 ft). A total of 21 cores were recovered in 23 attempts. Table 3-1 summarizes the results of sidewall coring operations at Well ER-12-3.

3.4 Sample Analyses

Six samples of drill cuttings and two sidewall core samples from various depths in Well ER-12-3 were submitted to the Hydrology, Geochemistry, and Geology Group of the Earth and Environmental Sciences Division at LANL for petrographic, mineralogic, and chemical analyses to aid in stratigraphic identification and for characterization of mineral alteration (WoldeGabriel, 2006a, b). Three conventional core samples from nearby core hole UE-12n#6 were also submitted to LANL for analysis to verify the stratigraphic assignment of older volcanic units in the area. Biostratigraphic analyses were performed on nine samples of drill cuttings from the Paleozoic sedimentary section in Well ER-12-3 (Harris, 2005). Table 3-2 lists the sample depths and the status of laboratory analyses for Well ER-12-3.

3.5 Geophysical Log Data

Geophysical logs were run in the borehole to further characterize the lithology, structure, and hydrologic properties of the rocks encountered, and to evaluate borehole conditions. Geophysical logging was conducted in two stages during drilling: prior to installation of the 13³/₈-in. casing at 743.1 m (2,438 ft), and after TD was reached at 1,496.0 m (4,908 ft). A complete listing of the logs, dates run, depths, and service companies is provided in Table 3-3. The logs are available from BN in Mercury, Nevada; copies are on file at the office of SNJV in Las Vegas, Nevada, and at the USGS Geologic Data Center and Core Library in Mercury, Nevada. Preliminary geophysical data from the logs are reproduced in Appendix D.

**Table 3-1
Sidewall Samples from Well ER-12-3**

Core Depth meters (feet)	Tool Used ^a	Recovery centimeters (inches)	Formation	Lithology
121.9 (400)	PG	4.1 (1.6)	Tuff of Holmes Road	Bedded tuff
182.9 (600)	PG	4.8 (1.9)	Mafic-poor Calico Hills	Bedded tuff
286.5 (940)	PG	4.8 (1.9)	Crater Flat Group, undivided	Bedded tuff
426.7 (1,400)	PG	4.6 (1.8)	Tunnel Formation, beds 4H	Bedded tuff
548.6 (1,800)	PG	3.8 (1.5)	Tub Spring Tuff	Nonwelded ash-flow tuff
640.1 (2,100)	PG	4.1 (1.6)	Tuff of Twin Peaks	Nonwelded ash-flow tuff
680.9 (2,234)	PG	3.5 (1.4)	Paleozoic carbonate rocks, undivided	Dolomite
684.3 (2,245)	PG	1.8 (0.7)	Paleozoic carbonate rocks, undivided	Dolomite
685.2 (2,248)	PG	3.0 (1.2)	Paleozoic carbonate rocks, undivided	Dolomite
687.9 (2,257)	PG	3.5 (1.4)	Paleozoic carbonate rocks, undivided	Dolomite
692.5 (2,272)	PG	3.0 (1.2)	Paleozoic carbonate rocks, undivided	Dolomite
707.1 (2,320)	PG	1.0 (0.4)	Paleozoic carbonate rocks, undivided	Dolomite
714.8 (2,345)	PG	2.5 (1.0)	Paleozoic carbonate rocks, undivided	Dolomite
730.0 (2,395)	PG	2.5 (1.0)	Paleozoic carbonate rocks, undivided	Dolomite
865.6 (2,840)	RS	1.5 (0.6)	Paleozoic carbonate rocks, undivided	Dolomite
883.9 (2,900)	RS	1.8 (0.7)	Paleozoic carbonate rocks, undivided	Dolomite
945.8 (3,103)	RS	2.5 (1.0)	Paleozoic carbonate rocks, undivided	Dolomite
946.1 (3,104)	RS	2.5 (1.0)	Paleozoic carbonate rocks, undivided	Dolomite
955.9 (3,136)	RS	2.8 (1.1)	Paleozoic carbonate rocks, undivided	Dolomite
995.2 (3,265)	RS	2.5 (1.0)	Paleozoic carbonate rocks, undivided	Dolomite
995.5 (3,266)	RS	3.0 (1.2)	Paleozoic carbonate rocks, undivided	Dolomite
1,033.3 (3,390)	RS	2.5 (1.0)	Paleozoic carbonate rocks, undivided	Dolomite
1,093.6 (3,588)	RS	2.5 (1.0)	Paleozoic carbonate rocks, undivided	Dolomite
1,152.8 (3,782)	RS	2.0 (0.8)	Paleozoic carbonate rocks, undivided	Dolomite
1,202.7 (3,946)	RS	1.2 (0.5)	Paleozoic carbonate rocks, undivided	Dolomite
1,210.1 (3,970)	RS	2.8 (1.1)	Paleozoic carbonate rocks, undivided	Dolomite
1,243.6 (4,080)	RS	1.7 (0.7)	Paleozoic carbonate rocks, undivided	Dolomite
1,253.9 (4,114)	RS	2.0 (0.8)	Paleozoic carbonate rocks, undivided	Limestone

Table 3-1
Sidewall Samples from Well ER-12-3, continued

Core Depth meters (feet)	Tool Used ^a	Recovery centimeters (inches)	Formation	Lithology
1,292.0 (4,239)	RS	1.0 (0.4)	Paleozoic carbonate rocks, undivided	Limestone
1,292.4 (4,240)	RS	0.5 (0.2)	Paleozoic carbonate rocks, undivided	Limestone
1,325.9 (4,350)	RS	1.7 (0.7)	Paleozoic carbonate rocks, undivided	Limestone
1,353.3 (4,440)	RS	2.2 (0.9)	Paleozoic carbonate rocks, undivided	Limestone
1,406.3 (4,614)	RS	2.0 (0.8)	Paleozoic carbonate rocks, undivided	Limestone
1,439.3 (4,722)	RS	3.8 (1.5)	Paleozoic carbonate rocks, undivided	Limestone
1,453.9 (4,770)	RS	2.5 (1.0)	Paleozoic carbonate rocks, undivided	Limestone

- a PG = percussion-gun sidewall coring tool; core diameter: 16 millimeters (0.63 in.)
 RS = rotary sidewall coring tool; core diameter: 23 millimeters (0.91 in.)

**Table 3-2
Status of Rock Sample Analyses for Well ER-12-3**

Depth ^a meters (feet)	Sample Type ^b	Analyses Performed ^c			
		Petrographic	Mineralogic (XRD)	Chemical (XRF)	Biostratigraphic
265.2 (870)	DC	AC	AC	AC	NP
286.5 (940)	PG	AC	AC	AC	NP
304.8 (1,000)	DC	AC	AC	AC	NP
621.8 (2,040)	DC	AC	AC	AC	NP
640.1 (2,100)	PG	AC	AC	AC	NP
673.6 (2,210)	DC	AC	AC	AC	NP
716.3 (2,350)	DC	NP	NP	NP	AC
823.0 (2,700)	DC	NP	NP	NP	AC
914.4 (3,000)	DC	NP	NP	NP	AC
1,036.3 (3,400)	DC	NP	NP	NP	AC
1,143.0 (3,750)	DC	NP	NP	NP	AC
1,258.8 (4,130)	DC	AC	AC	AC	NP
1,295.4 (4,250)	DC	NP	NP	NP	AC
1,341.1 (4,400)	DC	NP	NP	NP	AC
1,408.2 (4,620)	DC	AC	AC	AC	NP
1,417.3 (4,650)	DC	NP	NP	NP	AC
1,463.0 (4,800)	DC	NP	NP	NP	AC

a Depth for petrographic, mineralogic, and chemical analyses represents base of 3.0-m (10-ft) sample interval for drill cuttings samples. Depths for biostratigraphic analyses represent base of 15.2-m (50-ft) sample interval.

b Sample type: **DC** = drill cuttings; **PG** = percussion-gun sidewall core sample

c Status of analyses at the time of this writing: **AC** = analysis complete; **NP** = analysis not planned. Analysis type: **XRD** = x-ray diffraction; **XRF** = x-ray fluorescence.

Table 3-3
Well ER-12-3 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, lithologic determination, mineralogy, natural and man-made radiation, fracture identification	Halliburton Energy Services	04/07/2005 04/24/2005	SGR-1/GR-6 SGR-2/GR-9	741.6 (2,433) 1,482.2 (4,863)	365.8 (1,200) 731.5 (2,400)
* Six Arm Caliper / Gamma Ray	Borehole conditions, cement volume calculation, fracture identification	Halliburton Energy Services	04/03/2005 04/07/2005 04/23/2005 04/25/2005	CA6-1/ GR-2 CA6-2/ GR-4 CA6-3 ^c / GR-8 CA6-4/GR-14	666.3 (2,186) 744.9 (2,444) 1,491.4 (4,893) 1,492.6 (4,897)	9.1 (30) 371.9 (1,220) 731.5 (2,400) 731.5 (2,400)
*High Resolution Induction / Gamma Ray / Spontaneous Potential	Lithologic determination, stratigraphic correlation	Halliburton Energy Services	04/07/2005 04/24/2005	HRI-1/GR-6/SP-1 HRI-2/GR-10/SP-3	750.7 (2,463) 1,492.6 (4,897)	16.5 (54) 731.5 (2,400)
* Dual Laterolog / Spontaneous Potential	Lithologic determination, stratigraphic correlation, water saturation	Halliburton Energy Services	04/24/2005 04/25/2005	DLL-1 ^c /SP-2/GR-9 DLL-2/SP-3/GR-15	1,493.2 (4,899) 1,490.8 (4,891)	951.0 (3,120) 944.9 (3,100)
* Epithermal Neutron / Density	Total water content , rock porosity, stratigraphic correlation, lithologic determination	Halliburton Energy Services	04/03/2005 04/07/2005 04/24/2005	DSEN-1/SDL-1/GR-3 DSEN-2/SDL-2/GR-5 DSEN-3/SDL-3/GR-11	666.0 (2,185) 744.6 (2,443) 1,494.7 (4,904)	9.1 (30) 603.5 (1,980) 609.6 (2,000)
Electric Micro Imager	Lithologic characterization, structural analysis, fracture and void analysis.	Halliburton Energy Services	04/07/2005 04/23/2005 04/25/2005	EMI-1/GR-4 EMI-2 ^c /GR-8 EMI-3/GR-14	744.9 (2,444) 1,491.4 (4,893) 1,492.6 (4,897)	371.9 (1,220) 949.5 (3,115) 950.7 (3,119)
Full Wave Sonic - Waveform	Fracture identification	Halliburton Energy Services	04/24/2005	FWS-1/GR-12	1,491.7 (4,894)	944.9 (3,100)
* Full Wave Sonic - Delta-T	Porosity, seismic properties	Halliburton Energy Services	04/24/2005	FWS-1/GR-12	1,491.7 (4,894)	944.9 (3,100)
Temperature	Groundwater temperature, fracture identification	Halliburton Energy Services	04/03/2005 04/07/2005 04/23/2005	TL-1/GR-1 TL-2/GR-4 TL-3/GR-7	658.4 (2,160) 741.6 (2,433) 1,478.3 (4,850)	9.1 (30) 371.9 (1,220) 707.1(2,320)
Borehole Televiewer	Lithologic determination, fracture identification	Halliburton Energy Services	04/24/2005	BHTV-1/GR-13	1,463.0 (4,800)	950.7 (3,119)

Table 3-3
Well ER-12-3 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)
Percussion Gun Sidewall Coring Tool	Geologic samples	Halliburton Energy Services	04/07/2005	SWC-1	744.9 (2,444)	121.9 (400)
Rotary Sidewall Coring Tool	Geologic samples	Halliburton Energy Services	04/25/2005	RSWC-1	1,493.5 (4,900)	829.1 (2,720)
* Chemistry / Temperature Log	Groundwater chemistry and temperature, formation transmissivity	Desert Research Institute	04/26/2005	Chem-1/TL-4	1,495.3 (4,906)	953.4 (3,128)
* Thermal Flow Meter	Groundwater flow rate	Desert Research Institute	04/26/2005	HPFlow-1	1,485.9 (4,875)	954.9 (3,133)
True Vertical Depth Plot (Calculated from EMI logs)	Borehole deviation	Halliburton Energy Services	04/23/2005 04/25/2005	TVD-1 TVD-2	1,494.4 (4,903) 1,495.7 (4,907)	568.5 (1,865) 701.0 (2,300)

- a Logs presented in geophysical log summary, Appendix D, are indicated by *.
- b Drilled depth below ground surface.
- c Log was declared void.

This page intentionally left blank.

4.0 Geology and Hydrogeology

4.1 Introduction

This section describes the geology and hydrogeology of Well ER-12-3. The basis for the discussions in Section 4.0 is the detailed lithologic log of Well ER-12-3 presented in Appendix C. The detailed lithologic log was developed using drill cuttings and sidewall core samples, geophysical logs, and drilling parameters. Information from petrographic, mineralogic, and chemical analyses on selected lithologic samples from Well ER-12-3 (WoldeGabriel, 2006a, b) were incorporated into the detailed lithologic log. Additional information was obtained from biostratigraphic analyses (Harris, 2005) and borehole image analysis (Leavitt, 2005).

4.2 Geology

This section is divided into three discussions relating to the geology of Well ER-12-3. Section 4.2.1 describes the geologic setting of Rainier Mesa and Well ER-12-3. The stratigraphic and lithologic units penetrated at the well are discussed in Section 4.2.2. Because of the significant influence some alteration products have on the hydraulic properties of certain rocks, alteration of the rocks encountered at the well is discussed separately in Section 4.2.3. More detailed descriptions of the stratigraphy, lithology, and alteration of the rocks encountered are provided in the detailed lithologic log presented in Appendix C.

4.2.1 Geologic Setting

Well ER-12-3 was drilled from the top of Rainier Mesa (Figure 4-1). The mesa consists of a thick sequence of Miocene volcanic rocks erupted between 11.45 and 15.90 million years ago (Ma) from large calderas located nearby to the west (Sawyer et al., 1994). Rainier Mesa is capped by welded ash-flow tuff, and the underlying volcanic rocks consist mainly of highly bedded sequences of nonwelded ash-fall and reworked deposits and lesser intercalated welded ash-flow tuffs (Gibbons et al., 1963). The volcanic section at Rainier Mesa is similar in thickness and stratigraphic and lithologic composition as the volcanic section beneath central Yucca Flat (Prothro, 2005a).

The volcanic rocks at Rainier Mesa are draped unconformably over an irregular substrate of Paleozoic and late Precambrian sedimentary and Mesozoic intrusive rocks (SNJV, 2004). The volcanic rocks fill a north- to northeast-trending paleo-valley formed in the pre-Tertiary surface, resulting in a low amplitude synclinal form to volcanic rocks that cap the mesa (Gibbons et al., 1963). Paleozoic and late Precambrian sedimentary rocks in the area show considerable contractional deformation related to the east-vergent Belted Range thrust fault that

This page intentionally left blank.

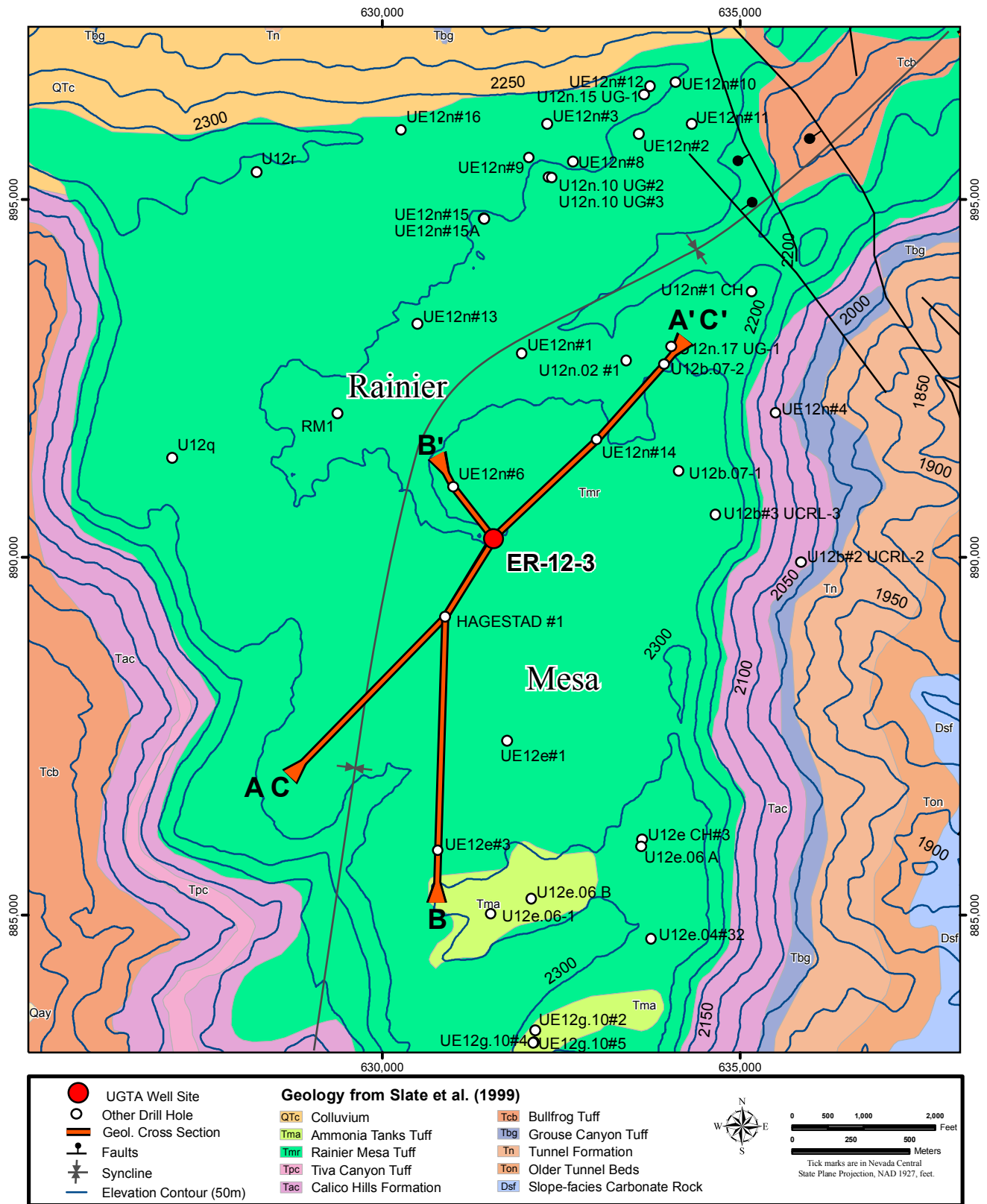


Figure 4-1
Surface Geologic Map of the Well ER-12-3 Site

This page intentionally left blank.

places Cambrian and late Precambrian siliciclastic rocks over Devonian and Silurian carbonate rocks beneath Rainier Mesa (Gibbons et al., 1963; Cole and Cashman, 1999). Numerous deep drill holes on the mesa constrain fairly well the location of the leading edge of the Belted Range thrust fault beneath the mesa (Cole et al., 1997). Granitic rocks dated at 100 Ma (Naeser and Maldonado, 1981) intrude Belted Range hanging wall rocks north of Rainier Mesa (Gibbons et al., 1963). A foreland imbricate thrust fault within the footwall of the Belted Range thrust fault places Devonian and Silurian carbonate rocks over Mississippian siliciclastic rocks just east of the Rainier Mesa (Cole and Cashman, 1999). Several high-angle normal faults offset the volcanic rocks at Rainier Mesa, however faults with greater than about 30 m (100 ft) of displacement are rare (Gibbons et al., 1963).

4.2.2 Stratigraphy and Lithology

The stratigraphic and lithologic units penetrated at Well ER-12-3 are illustrated in Figure 4-2, and the distribution of stratigraphic units in the vicinity of the well is shown in cross section in Figures 4-3 and 4-4. The determination of stratigraphic and lithologic units penetrated by Well ER-12-3 was greatly aided by examination of, and correlation with, nearby core hole UE-12n#6 drilled in 1973 to explore geologic conditions in the vicinity of N-Tunnel. Core hole UE-12n#6 is located 278.6 m (914 ft) northwest of Well ER-12-3. The exploratory hole was continuously cored to a depth of 706.2 m (2,317 ft) and thus provides excellent lithologic samples of the volcanic section in the immediate vicinity of Well ER-12-3. Geophysical well logs available from both Well ER-12-3 and hole UE-12n#6 allowed precise correlation of contacts between the drill holes.

Drilling at Well ER-12-3 began in moderately welded ash-flow tuff of the Rainier Mesa Tuff which forms the ground surface in the vicinity of the well (Gibbons et al., 1963). The Rainier Mesa Tuff was encountered from surface to a depth of 105.5 m (346 ft). The formation consists mostly of moderately welded, devitrified ash-flow tuff. The basal 17.7 m (58 ft) however, consists of vitric nonwelded ash-flow tuff. Only the lower mafic-poor member of the formation was encountered in Well ER-12-3. The stratigraphic assignment of Rainier Mesa Tuff is based on surface mapping (Gibbons et al., 1963) and the primary mineralogy, which consists of moderate amounts of quartz, feldspar, and biotite, only rare volcanic lithic fragments, and no sphene. The Rainier Mesa Tuff was erupted 11.6 Ma (Sawyer et al., 1994) from the Timber Mountain caldera complex located southwest of the well location.

Below the Rainier Mesa Tuff, a 211.5-m (694-ft) sequence of bedded tuff was penetrated from 105.5 to 317.0 m (346 to 1,040 ft). The tuffs are vitric (i.e., unaltered) to a depth of 291.1 m

This page intentionally left blank.

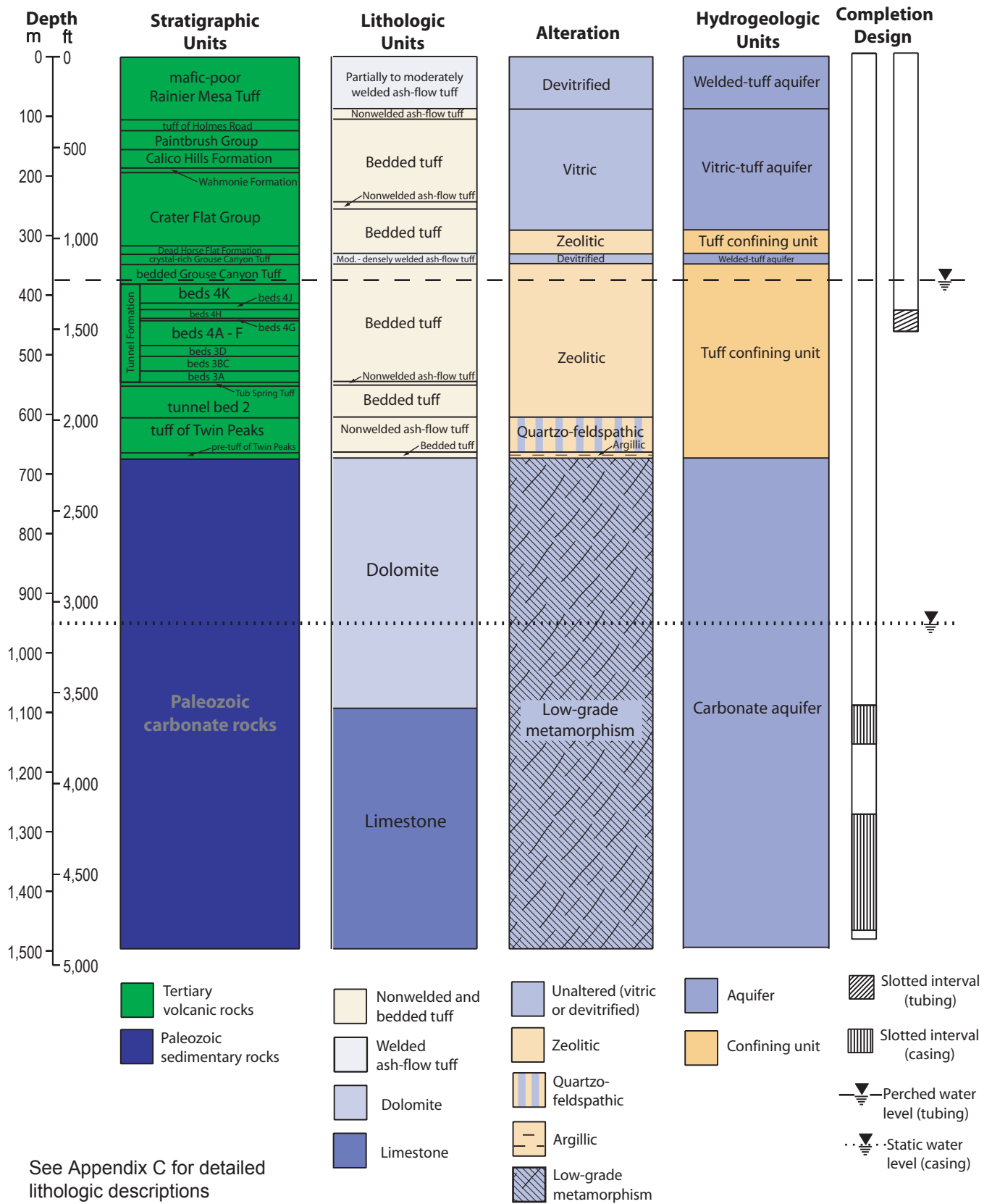


Figure 4-2
Geology and Hydrogeology for Well ER-12-3

This page intentionally left blank.

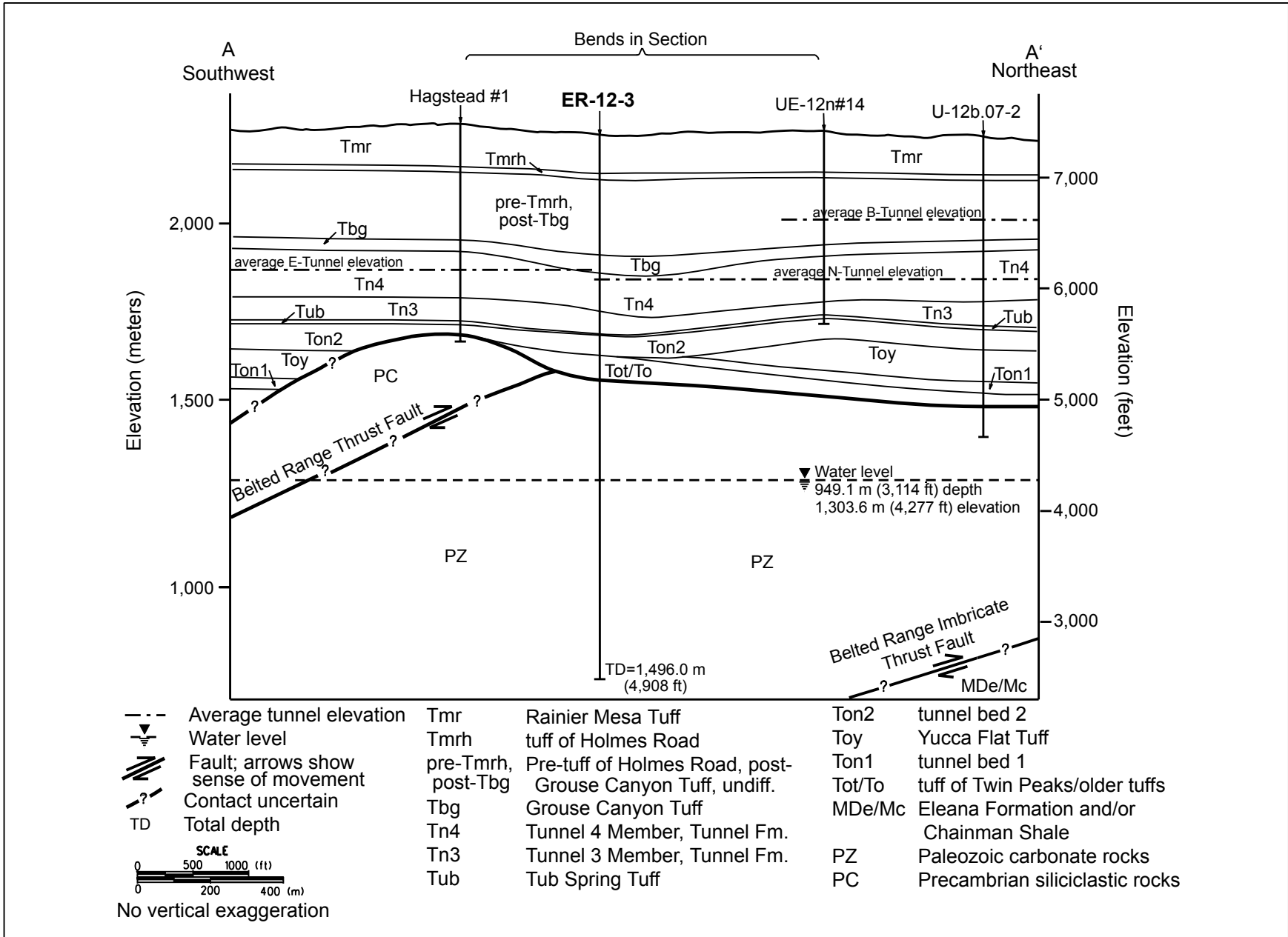


Figure 4-3
Southwest-Northeast Geologic Cross Section A-A' through Well ER-12-3

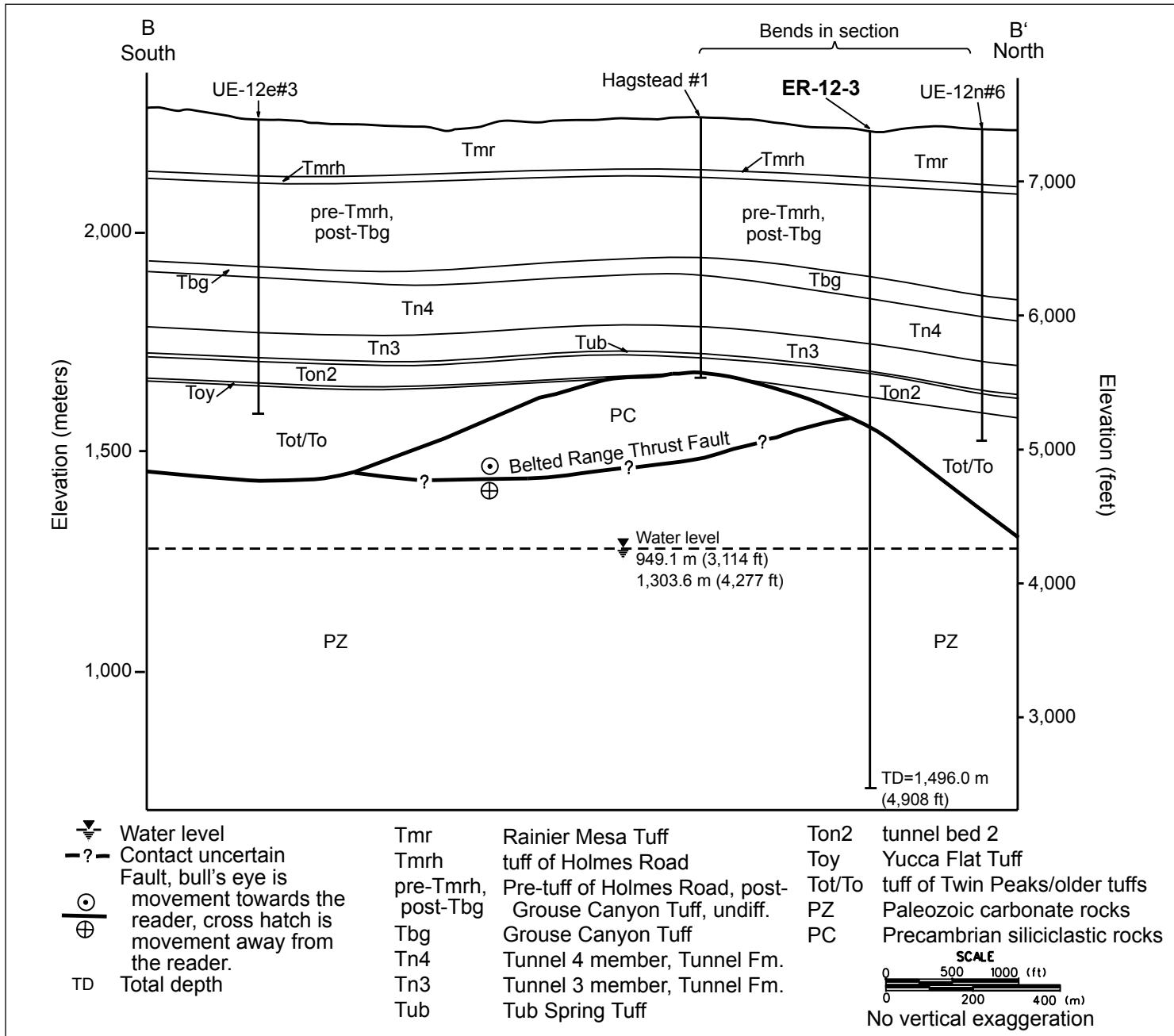


Figure 4-4
South-North Geologic Cross Section B-B' through Well ER-12-3

(955 ft), becoming zeolitic below. The interval comprises various stratigraphic units including, in descending order, the tuff of Holmes Road, Paintbrush Group, Calico Hills Formation, Wahmonie Formation, Crater Flat Group, and the Dead Horse Flat Formation. These units were erupted from various sources to the west and south of Well ER-12-3 between approximately 12.5 and 13.5 Ma (Sawyer et al., 1994).

Moderately to densely welded ash-flow tuff was penetrated from 330.7 to 348.4 m (1,085 to 1,143 ft). This 17.8-m (58-ft) thick interval of devitrified ash-flow tuff is assigned to the crystal-rich Grouse Canyon Tuff based on the general absence of quartz and biotite. The Grouse Canyon Tuff was erupted 13.7 Ma from the Silent Canyon caldera complex located northwest of Well ER-12-3 (Sawyer et al., 1994).

A 197.8-m (649-ft) thick, monotonous interval of zeolitic bedded tuff occurs below the welded Grouse Canyon Tuff, from 348.4 to 546.2 m (1,143 to 1,792 ft). This interval includes the bedded Grouse Canyon Tuff and the Tunnel Formation, which were erupted between 14.0 and 14.9 Ma from unknown sources (Sawyer et al., 1994). Analysis of the borehole image log indicates bedding within the interval generally strikes east-west and dips 12 to 20 degrees to the north.

Nonwelded zeolitic ash-flow tuff assigned to the Tub Spring Tuff was encountered from 546.2 to 551.4 m (1,792 to 1,809 ft). The assignment of Tub Spring Tuff is based on stratigraphic position below beds 3A of the Tunnel Formation and on primary mineralogy, which is characterized by only scarce felsic phenocrysts and no biotite. Although the Tub Spring Tuff is relatively thin and similar lithologically (e.g., nonwelded, zeolitic tuff) to the over- and underlying intervals, the unit is an important marker bed in the area. To the north, beneath Aqueduct Mesa, the Tub Spring Tuff is highly welded. The Tub Spring Tuff was erupted 14.9 Ma from an unknown source (Sawyer et al., 1994). The borehole image log from Well ER-12-3 indicates that the Tub Spring Tuff strikes N 28° E and dips 12 degrees to the northwest.

Below the Tub Spring Tuff, Well ER-12-3 penetrated 53.9 m (177 ft) of zeolitic bedded tuff that overlies 58.8 m (193 ft) of quartzo-feldspathic and partially argillic nonwelded ash-flow tuff. The interval of bedded tuff is assigned to tunnel bed 2, based on its bedded nature and stratigraphic position directly below the Tub Spring Tuff. The primary mineralogy is generally consistent with tunnel bed 2 but the lack of observed sphene may indicate the unit is tunnel bed 1. The underlying ash-flow unit is assigned to the tuff of Twin Peaks based on its ash-flow tuff lithology and general abundance of felsic phenocrysts and biotite, although the lack of observed sphene may indicate the unit is Yucca Flat or Redrock Valley Tuff. Volcanic units below the Tub Spring

Tuff were erupted from unknown sources between 14.9 and 15.9 Ma (Sawyer et al., 1994). The bedding within this interval generally strikes east-west and dips 16 degrees to the north, based on analysis of the borehole image log.

The base of the volcanic section at Well ER-12-3 consists of 9.4 m (31 ft) of mostly argillic bedded tuff that lies directly on Paleozoic dolomite. The occurrence of argillic tuffs directly overlying pre-Tertiary rocks is common in the NTS vicinity, particularly beneath Yucca Flat (Prothro, 2005b).

Well ER-12-3 encountered dark-gray to black dolomite at a depth of 673.6 m (2,210 ft). The dolomite becomes lighter in color and brecciated from 1,167.4 to 1,250.3 m (3,830 to 4,102 ft). At a depth of 1,255.8 m (4,120 ft), Well ER-12-3 encountered medium-dark-gray to black limestone. The well reached TD in limestone at a depth of 1,496.0 m (4,908 ft).

Biostratigraphic analyses suggest a Silurian-Devonian age for the dolomite above approximately 853.4 m (2,800 ft), and a Middle to Late Ordovician age for dolomite from approximately 853.4 to 1,143.0 m (2,800 to 3,750 ft) (Harris, 2005). The age, dark color, and lithology of the rocks from approximately 853.4 to 1,143.0 m (2,800 to 3,750 ft) are consistent with the Ely Springs Dolomite. Although no fossils were recovered from the 245.7 m (806 ft) of limestone encountered below the dolomite, the rocks must be either Middle Ordovician to Late Cambrian or Pennsylvanian because these are the only time periods that produced thick limestone units in the area.

Conodont color alteration index values and heavy mineral concentrates from biostratigraphic analyses (Harris, 2005) indicate the dolomite and limestone have undergone low-grade metamorphism. The presence of low-grade metamorphism within the Paleozoic rocks at Well ER-12-3 is not surprising, considering the proximity of these rocks to Mesozoic granitic rocks that are exposed at the surface approximately 2,740 m (9,000 ft) north of the well.

Structural information from the bore hole image log (Leavitt, 2005) indicates that the Paleozoic rocks penetrated at Well ER-12-3 dip from 40 to 70 degrees to the southwest and southeast. Major changes in stratigraphic dip appear to be bounded by faults which are typically associated with increased fracturing. The dolomite section is fractured and brecciated, particularly the lower portion, while the limestone section shows considerable internal folding. The absence of the Middle Ordovician Eureka Quartzite between the Middle to Late Ordovician-age dolomite and the underlying limestone indicates that a fault is present between the dolomite and limestone. The

increased fracturing and brecciation observed in the lower portion of the dolomite may represent hanging-wall deformation associated with this fault.

4.2.3 Alteration

The volcanic rocks penetrated at Well ER-12-3 are generally unaltered above 291.1 m (955 ft). These rocks include nonwelded and bedded tuffs that have retained their original vitric (i.e., glassy) character. The welded portions of the Rainier Mesa Tuff from the surface to 87.8 m (288 ft) are devitrified as a result of recrystallization of the original glass matrix to microcrystalline quartz and feldspar during cooling and degassing as the welding process proceeded. Below 291.1 m (955 ft), to a depth of 330.7 m (1,085 ft), the original glass matrix of the nonwelded and bedded tuffs has been altered to zeolite. The welded Grouse Canyon Tuff from 330.7 to 348.4 m (1,085 to 1,143 ft) is devitrified. Units below the welded Grouse Canyon Tuff are generally zeolitic down to the top of tuff of Twin Peaks at 605.3 m (1,986 ft). The nonwelded ash-flow tuff that comprises the tuff of Twin Peaks is quartzo-feldspathic, characterized by secondary felsic mineralization that is mineralogically similar to devitrification. Argillic alteration is also present within the tuff of Twin Peaks. Argillic alteration becomes pervasive within the bedded tuff interval that occurs between the tuff of Twin Peaks and the top of pre-Tertiary rocks at 673.6 m (2,210 ft).

The pre-Tertiary dolomite and limestone penetrated at Well ER-12-3 have conodont alteration index values and mineral assemblages indicative of low-grade metamorphism. The dolomite section from 673.6 to 1,167.4 m (2,210 to 3,830 ft) includes the low-grade metamorphic minerals phlogopite and pyroxene (Harris, 2005). Conodont alteration index values indicate maximum temperatures ranging from 300 to 490 degrees Celsius (°C) (572 to 914 degrees Fahrenheit [°F]). Dolomite from 1,167.4 to 1,250.3 m (3,830 to 4,102 ft) is highly brecciated, with a recrystallized dolomite matrix containing sparse but ubiquitous iron-oxide mineralization. The limestone from 1,250.3 to 1,496.0 m (4,102 to 4,908 ft) is pyritic and contains the low-grade metamorphic minerals tremolite and amphibole.

4.3 Predicted and Actual Geology

The geology encountered at Well ER-12-3 is very similar to that predicted prior to drilling (Figure 4-5). This is mainly due to the large knowledge base and excellent surface and subsurface control for Tertiary volcanic rocks in the area, including nearby core hole UE-12n#6. Information on stratigraphic and structural relationships of the pre-Tertiary rocks in the area is

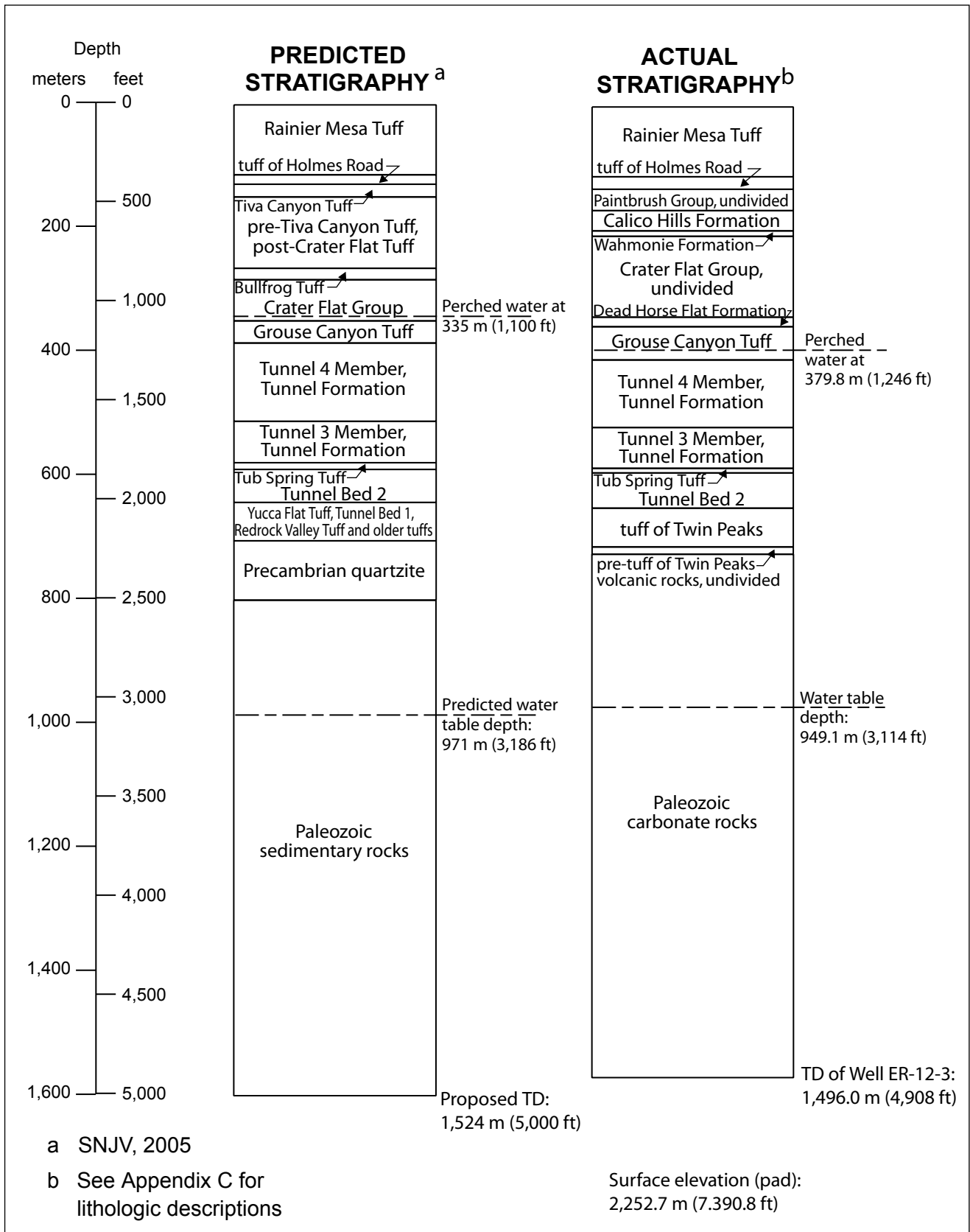


Figure 4-5
Predicted and Actual Stratigraphy at Well ER-12-3

much more limited. In addition, the geology of the pre-Tertiary rocks is more complex than that of the overlying volcanic rocks. Stratigraphic contacts within the volcanic section are typically within 6 m (20 ft) of those predicted, with most contacts slightly higher than predicted. However, the top of zeolitic alteration was encountered at 291.1 m (955 ft) in Well ER-12-3, which is 22.9 m (88 ft) lower than predicted. The lithologic composition of the volcanic section is consistent with that predicted prior to drilling.

Well ER-12-3 encountered pre-Tertiary rocks at 673.6 m (2,210 ft), only 3.0 m (10 ft) deeper than predicted. It was predicted, however, that approximately 91 m (300 ft) of Precambrian quartzite composing the leading edge of the east-directed Belted Range thrust sheet would be penetrated below Tertiary volcanic rocks and above Paleozoic carbonate rocks within the footwall of the thrust fault. Instead, footwall rocks consisting of Silurian-Devonian dolomite (Harris, 2005) were encountered directly below volcanic rocks, indicating that the leading edge of the Belted Range thrust fault is west of Well ER-12-3. The well reached TD within Paleozoic limestone at a depth of 1,496.0 m (4,908 ft).

4.4 Hydrogeology

Welded Rainier Mesa Tuff penetrated from the surface to 87.8 m (288 ft) in Well ER-12-3 is classified hydrogeologically as welded-tuff aquifer due to the dense and brittle nature of welded ash-flow tuffs, such as the Rainier Mesa Tuff, which tend to support well developed fractures (Winograd and Thordarson, 1975; Lacznik et al., 1996). The vitric nonwelded and bedded tuffs encountered from 87.8 to 291.1 m (288 to 955 ft) are classified as vitric-tuff aquifers due to the relatively high effective matrix porosity of these low-density rocks. The mostly zeolitic nonwelded and bedded tuffs encountered from 291.1 to 673.6 m (955 to 2,210 ft) are classified as tuff confining units (TCU) because of the low effective porosity associated with zeolitic alteration. The welded Grouse Canyon Tuff penetrated from 330.7 to 348.4 m (1,085 to 1,143 ft) forms a relatively thin welded-tuff aquifer intercalated within the much thicker section of TCU. The Paleozoic dolomite and limestone encountered below the volcanic rocks are classified together as carbonate aquifer because of the fractured and transmissive character of carbonate rocks in the region (Winograd and Thordarson, 1975; Lacznik et al., 1996). An interpretation of the possible distribution of hydrogeologic units at Well ER-12-3 is shown in cross section on Figure 4-6.

The depth to the regional water table at Well ER-12-3 was estimated at 970.8 m (3,185 ft) prior to drilling. As of June 11, 2005, the static fluid level (pre-development) at Well ER-12-3 was at a depth of 949.1 m (3,113.7 ft) within Paleozoic dolomite (SNJV, 2005b). Although the volcanic

This page intentionally left blank.

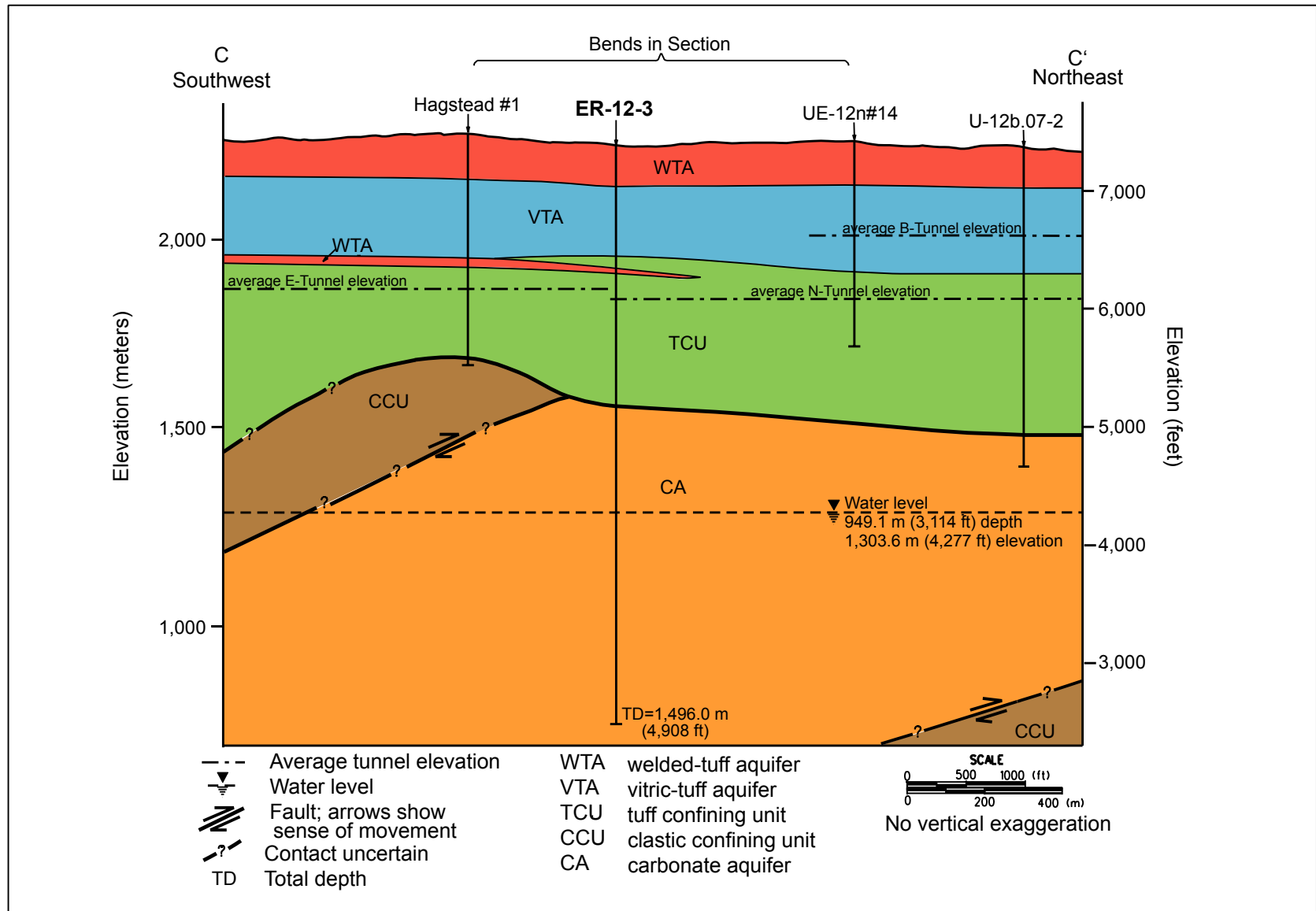


Figure 4-6
Southwest-Northeast Hydrogeologic Cross Section C-C' through Well ER-12-3

This page intentionally left blank.

rocks and upper portion of the Paleozoic sedimentary rocks penetrated at Well ER-12-3 are above the regional water table, water production was initially observed during drilling at a depth of 419.7 m (1,377 ft) within zeolitic tuffs. This occurrence of formation water within zeolitic tuffs approximately 529.4 m (1,737 ft) above the regional water table at Well ER-12-3 is not surprising. Limited water production is common within zeolitic tuffs at Rainier Mesa, and has been observed in many drill holes and tunnels in the area (Winograd and Thordarson, 1975; Laczniaik et al., 1996).

This page intentionally left blank.

5.0 Hydrology

5.1 Preliminary Water-Level Information

Prior to drilling, the water level within the LCA at Well ER-12-3 was estimated to be 970.8 m (3,185 ft) below ground surface, with a possibility of perched water below 334 m (1,096 ft) (SNJV, 2005a). Perched water was encountered at and below 419.7 m (1,377 ft) in the volcanic section. Measurements made after TD was reached indicate that the potentiometric surface associated with the LCA is slightly higher than predicted. On April 24, 2005, two days after TD of the well was reached, the fluid level was determined to be at 949.8 m (3,116 ft) by HES during the Borehole Televiewer run. The pre-development water level in the well on June 11, 2005, 49 days after TD of the well was reached, was tagged at 949.1 m (3,113.7 ft) by SNJV personnel (SNJV, 2005b). The water level inside the piezometer string, isolated within volcanic rocks outside of the 13³/₈-in. casing, was measured at 379.9 m (1,246.3 ft) by SNJV on June 11, 2005 (SNJV, 2005b). Results of well development and hydraulic testing in Well ER-12-3 are outside the scope of this report and will be reported separately.

5.2 Water Production

Water production was estimated during drilling of Well ER-12-3 on the basis of lithium bromide dilution data as measured by SNJV field personnel. Water production was first detected at the depth of about 419.7 m (1,377 ft) within zeolitic bedded tuff of the TCU. Another perched water zone was detected at 468.5 m (1,537 ft). Below a depth of about 487.7 m (1,600 ft), the hole continued to produce between 19 and 76 liters per minute (lpm) (5 and 20 gallons per minute [gpm]) in the TCU. As drilling progressed into the LCA below the depth of 673.6 m (2,210 ft), the hole began to produce slightly more water (up to 114 lpm [30 gpm]). The casing installed to 799.2 m (2,622 ft) sealed off the perched water zones and upper portion of the LCA. During drilling in the LCA between 799.2 and 989.7 m (2,622 and 3,247 ft), the hole produced no detectable water. Below this depth small amounts of water (up to 95 lpm [25 gpm]) were produced. Water production increased gradually until, at a depth of 1,112.5 m (3,650 ft), it was approximately 284 lpm (75 gpm). The amount of water produced fluctuated between 170 and 284 lpm (45 and 75 gpm), until a depth of approximately 1,481.3 m (4,860 ft) was attained. Water production then increased to about 389 lpm (100 gpm) and remained at that level the remainder of the drilling operations. Estimated water production rates during drilling are presented graphically in Appendix A-1.

5.3 Preliminary Flow Meter Data

Flow meter data, along with temperature, electrical conductivity (EC), and pH measurements, can be used to characterize borehole fluid variability, which may indicate inflow and outflow zones. Desert Research Institute (DRI) personnel made measurements with their thermal flow meter at 13 locations within the LCA between the depths 954.9 and 1,485.9 m (3,133 and 4,875 ft) shortly after drilling was completed. The thermal flow meter data indicate upward flow of approximately 1.9 lpm (0.5 gpm) throughout most of the saturated interval of the borehole and downward flow of approximately 3.8 lpm (1.0 gpm) near the bottom (the lowermost three measurement locations between 1,402.1 and 1,485.9 m [4,600 and 4,875 ft]).

In addition, DRI ran a chemistry log, which included measurements of temperature, pH and EC from 953.4 to 1,495.3 m (3,128 to 4,906 ft). Temperature in the well increased gradually with depth from 29.4 °C (85.0 °F) at 953.4 m (3,128 ft), to a maximum of 35.6 °C (96.0 °F) at 1,495.3 m (4,906 ft). There were no temperature variations that would indicate major inflow or outflow zones. The EC values increased rapidly below a depth of 1,280.2 m (4,200 ft), reaching a maximum at 1,417.3 m (4,650 ft) and decreasing again below that depth. The pH varied between 7.1 and 8.9, with the maximum at the top of the logged interval and the minimum at a depth of about 1,386.8 m (4,550 ft). The pH at the bottom of the borehole was 7.8.

Based on DRI's preliminary interpretation of these data (Lyles, 2005) groundwater is thought to be entering the borehole between 1,371.6 and 1,402.1 m (4,500 and 4,600 ft).

5.4 Preliminary Groundwater Characterization Samples

Following geophysical logging, on April 26, 2005, DRI collected preliminary groundwater characterization samples within the open borehole. Two 6-liter samples were collected at the depths of 1,127.8 and 1,386.8 m (3,700 and 4,550 ft). Analytical data from these initial samples, 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-12-3 consisted of circulating fluid for 30 minutes to clean the borehole prior to the final logging operation.

This page intentionally left blank.

7.0 Well Completion

7.1 Introduction

Well completion refers to the installation in a borehole of a string of tubing 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 placed between or above the open intervals to isolate them. The tubing or casing serves as a conduit for insertion of a pump in the well, for inserting devices for measuring fluid level, and for sampling, so that accurate potentiometric and water chemistry data can be collected from known portions of the borehole.

The proposed well completion design for Well ER-12-3 as presented in the *Rainier Mesa-Shoshone Mountain Hydrogeologic Investigation Wells Drilling and Completion Criteria* (SNJV, 2005a) is described in Section 7.2.1, and the actual well completion design, based on the hydrogeology encountered in the borehole, is presented in Section 7.2.3. The completion method is presented in Section 7.3. Figure 7-1 is a schematic diagram of the final well-completion design for the well, and Figure 7-2 shows a plan view and profile of the wellhead surface completion. Table 7-1 is a construction summary for the completion string and piezometer string.

7.2 Well Completion Design

The final completion design differs somewhat from the proposed design, as described in the following sections.

7.2.1 Proposed Completion Design

The original completion design (presented in SNJV, 2005a) was based on the assumption that Well ER-12-3 would penetrate Precambrian quartzite (lower clastic confining unit) that forms the upper plate of the Belted Range thrust fault and reach TD within the LCA. The 13³/₈-in. casing was intended to extend to the depth of approximately 731.5 m (2,400 ft) and isolate the LCA from the overlying lower clastic confining unit and the volcanic section (TCU). A piezometer tube was to be positioned outside the 13³/₈-in. intermediate casing, to monitor perched water zones within the TCU, if any were encountered. The bottom portion of this tubing string would not necessarily be gravel-packed or cemented in place.

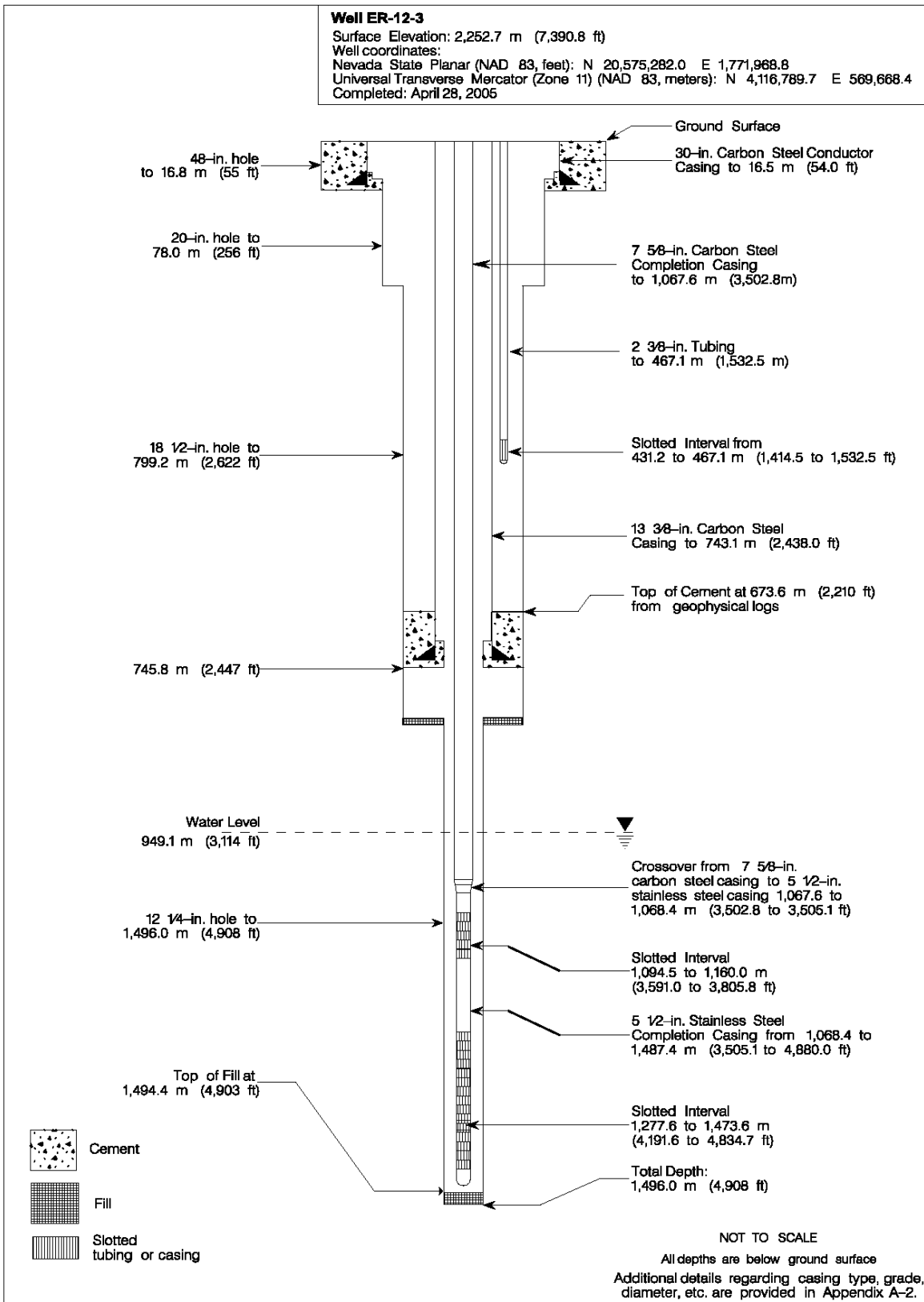


Figure 7-1
As-Built Completion Schematic for Well ER-12-3

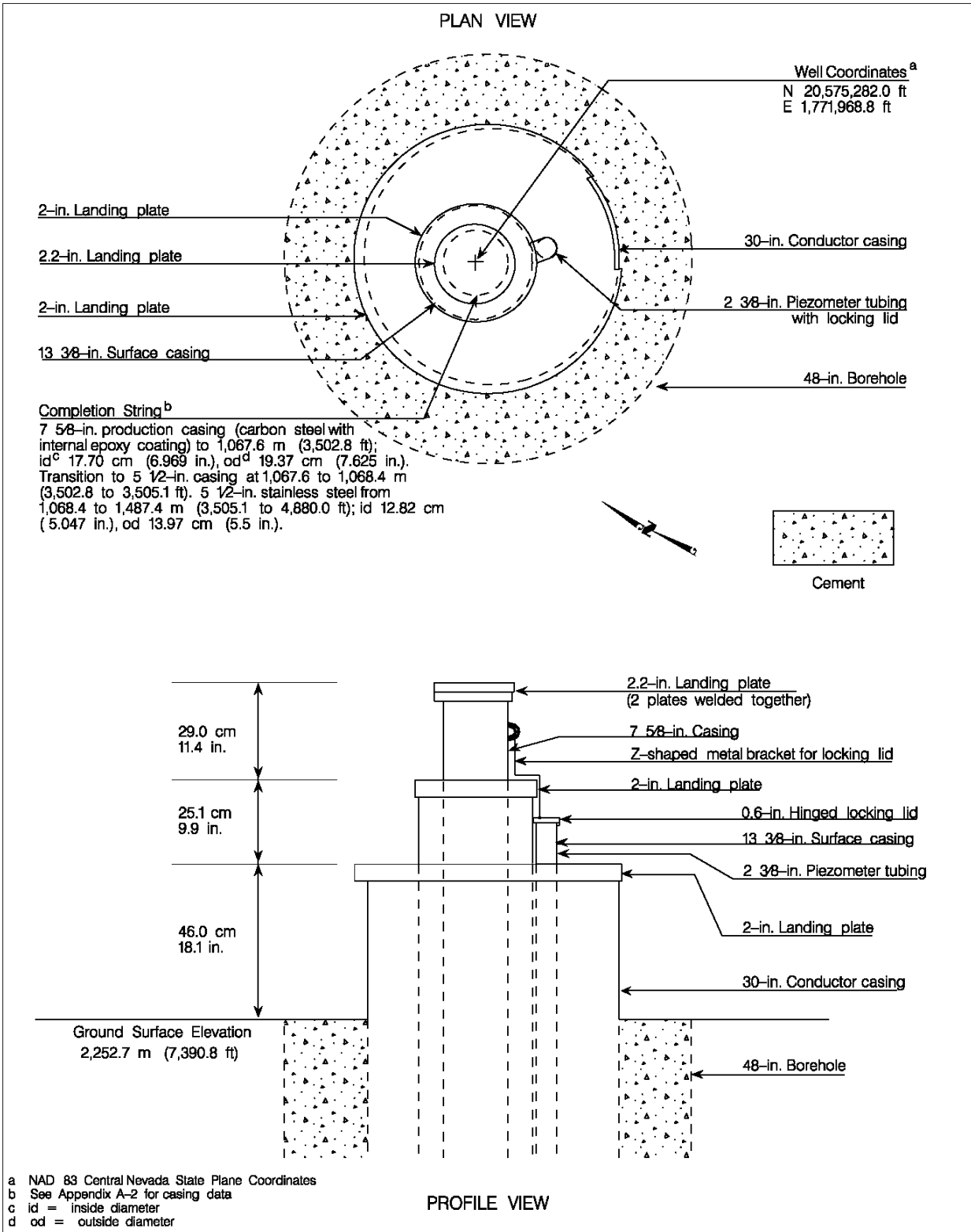


Figure 7-2
Wellhead Diagram for Well ER-12-3

**Table 7-1
Well ER-12-3 Completion String Construction Summary**

Tubing/Casing Type	Configuration meters (feet)		Cement meters (feet)	Sand/Gravel meters (feet)
2 ³ / ₈ -in. carbon-steel tubing	0 to 467.1 (0 to 1,532.5)	Blank 0 to 431.2 (0 to 1,414.5)	None	None
		Slotted and bull-nosed 431.2 to 467.1 (1,414.5 to 1,532.5)		
7 ⁵ / ₈ -in. carbon-steel production casing with internal epoxy coating	0 to 1,067.6 (0 to 3,502.8)	Blank	None	None
7 ⁵ / ₈ -in. to 5 ¹ / ₂ -in. cross-over sub, carbon steel, with stainless-steel double pin	1067.6 to 1,068.4 (3,502.8 to 3,505.1)	Blank		
5 ¹ / ₂ -in. stainless-steel production casing	1,068.4 to 1,094.5 (3,502.8 to 3,591.0)	Blank		
	1,094.5 to 1,160.0 (3,591.0 to 3,805.8)	5 consecutive slotted joints		
	1,160.0 to 1,277.6 (3,805.8 to 4,191.6)	Blank		
	1,277.6 to 1,473.6 (4,191.6 to 4,834.7)	15 consecutive slotted joints		
	1,473.6 to 1,487.4 (4,834.7 to 4,880.0)	Blank and bull-nosed		

The well was planned to be completed with a single casing string of 5¹/₂-in. stainless-steel casing suspended from 7⁵/₈-in. carbon-steel casing and extending into the LCA. The 5¹/₂-in. casing within the LCA would be slotted and gravel-packed across at least one water-producing zone, which would be isolated from other slotted intervals with cement. The primary goal of the proposed completion design was to provide groundwater production data from the LCA, and to provide access to groundwater, if present, within the TCU for monitoring and sampling.

7.2.2 As-Built Completion Design

The design of the Well ER-12-3 completion was determined through consultation with members of the UGTA Technical Working Group, on the basis of onsite evaluation of data such as lithology and water production, drilling data, and data from various geophysical logs.

Figure 7-1 shows that both the 2³/₈-in. carbon-steel piezometer tube and the main completion string were installed in Well ER-12-3 as planned. The piezometer tube was placed in the annular space between the 13³/₈-in. surface casing and the borehole wall at a depth of 467.1 m (1,532.5 ft). The tubing string includes four contiguous slotted joints in the interval 431.2 to 467.1 m (1,414.5 to 1,532.5 ft). The bottom of the tubing is bull-nosed with a drain hole approximately 0.32 cm (0.125-in.) in size. The openings in each slotted tubing joint are 0.32 cm (0.125 in.) wide and 6.67 cm (2.625 in.) long.

The main completion string, a single casing string of 5¹/₂-in. stainless steel casing suspended from 7⁵/₈-in. carbon-steel casing, was set at the depth of 1,487.4 m (4,880.0 ft). This casing is slotted in the intervals 1,094.5 to 1,160.0 m (3,591.0 to 3,805.8 ft) and 1,277.6 to 1,473.6 m (4,191.6 to 4,834.7 ft). The lower slotted section consists of fifteen consecutive slotted joints, and the upper slotted section consists of five consecutive slotted joints. The openings in each slotted casing joint are 0.158 cm (0.0624 in.) wide and 5.08 cm (2.0 in.) long. The slots are arranged in rows of 18, with rows staggered 10 degrees on 7.62-cm (3-in.) centers. The production casing was installed in the open borehole with no gravel pack or cement; therefore, the two slotted intervals are not isolated from each other or from formations above. The slotted intervals access the entire open borehole from the bottom of the cement associated with the 13³/₈-in. casing at 745.8 m (2,447 ft) to the bottom of the hole at 1,496.0 m (4,908 ft).

7.2.3 Rationale for Differences between Planned and Actual Well Design

The proposed completion design for Well ER-12-3 was based on the expectation that the well would encounter discrete water producing intervals within the LCA. However, because the LCA produced less water than expected, and only a single interval produced water at a significant rate, it was unnecessary to isolate the two slotted zones. Gravel-packing and cementing of the production casing were therefore not necessary, and the annulus of the completion string was left unstemmed. The primary objectives of constructing a well isolated within the LCA, and a piezometer providing access to groundwater within the TCU were achieved. See Figure 4-2 for a depiction of the position of the slotted intervals in relation to the borehole geology.

7.3 Well Completion Method

The 2³/₈-in. carbon-steel piezometer tube was inserted into the annular space outside the 13³/₈-in. casing on April 10, 2005, immediately after installation of the 13³/₈-in. casing, and before drilling of the 31.1-cm (12.25-in.) hole began. In the upper part of the annulus, above the bottom of the 30-in. conductor casing set at the depth of 16.5 m (54 ft), the tubing sits between the two casings. Below, this annular space is defined by the 13³/₈-in casing and the borehole wall. No gravel-pack or cement was emplaced with the piezometer string.

Well completion activities began on April 28, 2005, when the casing crew landed the production casing at 1,487.4 m (4,880.0 ft). No gravel pack or cement was used with this casing string (Figure 7-1). All well construction materials were inspected according to relevant procedures, as listed in SNJV (2005a). Standard decontamination procedures were employed to prevent the introduction of contaminants into the well.

The drill rig was released after the production casing was installed. Hydrologic testing was planned as a separate effort, so a pump was not installed in the well, and no well-development or pumping tests were conducted immediately after completion.

8.0 Planned and Actual Costs and Scheduling

The original BN cost model developed for Well ER-12-3 was based on drilling to the planned TD of 1,524.0 m (5,000 ft). The drilling program baseline projected that it would require 34 days to drill and complete the well.

It took 37 days to construct Well ER-12-3. The surface hole was drilled 37.2 m (122 ft) deeper than the original estimated depth (762.0 m [2,500 ft]) to reach a good casing point. Actual drilling time was less than anticipated, but 5½ days were spent on rig repairs. The main hole was terminated 28.0 m (92 ft) short of the planned TD because no additional information was expected below that point. A graphical comparison, by day, of planned and actual well-construction activities is presented in Figure 8-1.

The cost analysis for Well ER-12-3 begins with construction of the conductor hole by BN and the cost of mobilizing the UDI drill rig to the Well ER-12-3 site. The cost of building roads, the drill pad, and sumps is not included, and the cost of well-site support by SNJV personnel is not included. The total construction cost for Well ER-12-3 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 geophysical logging); and charges by BN for mobilization and demobilization of equipment, construction of the conductor hole, cementing services, the piezometer string, radiation technicians, inspection services, and geotechnical consultation.

The total planned cost for constructing Well ER-12-3, was \$3,164,411. The actual cost was \$3,186,336, or 0.7 percent more than the planned cost. Figure 8-2 presents a comparison of the planned and actual costs, by day, for constructing Well ER-12-3.

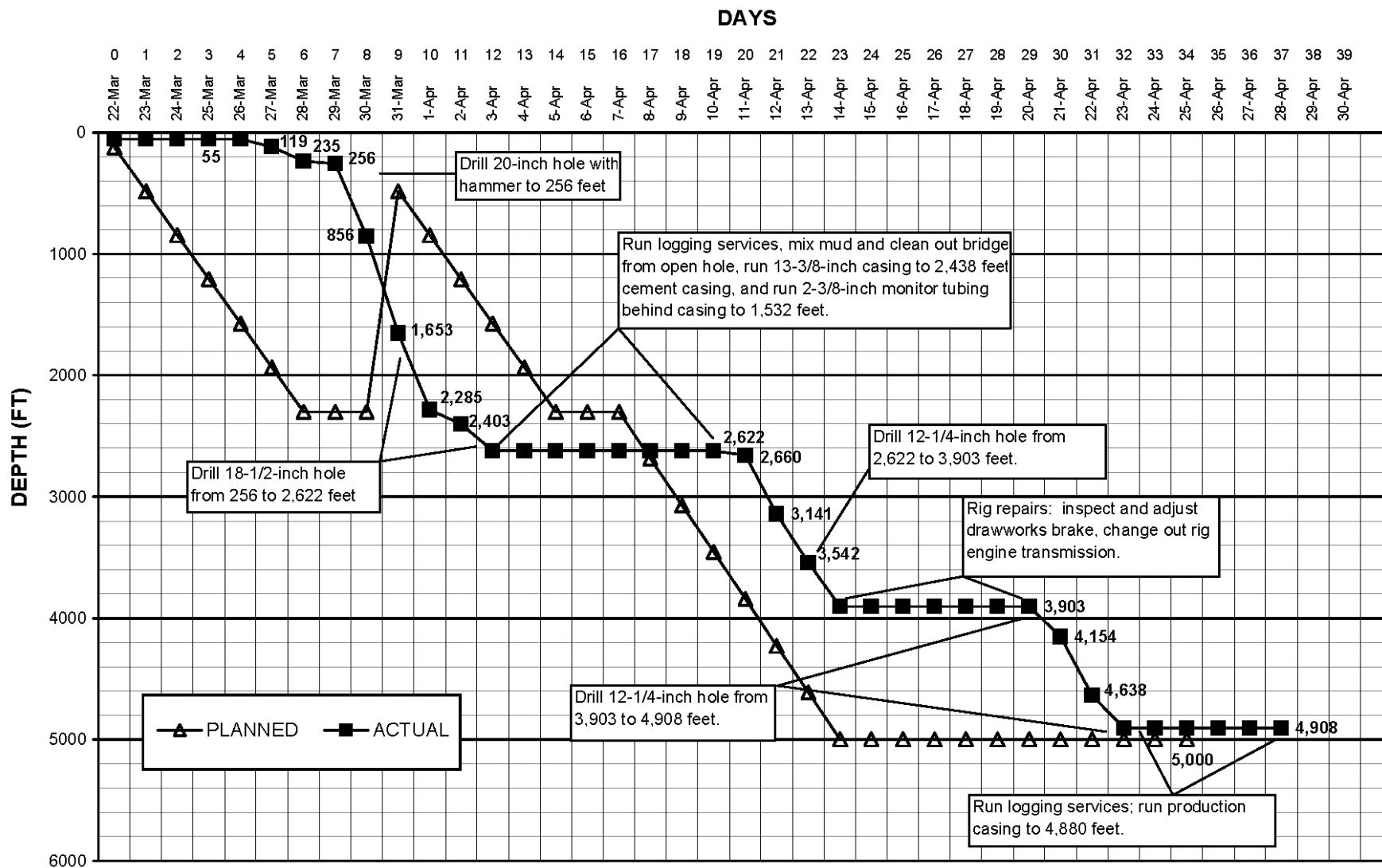


Figure 8-1
Planned and Actual Construction Progress for Well ER-12-3

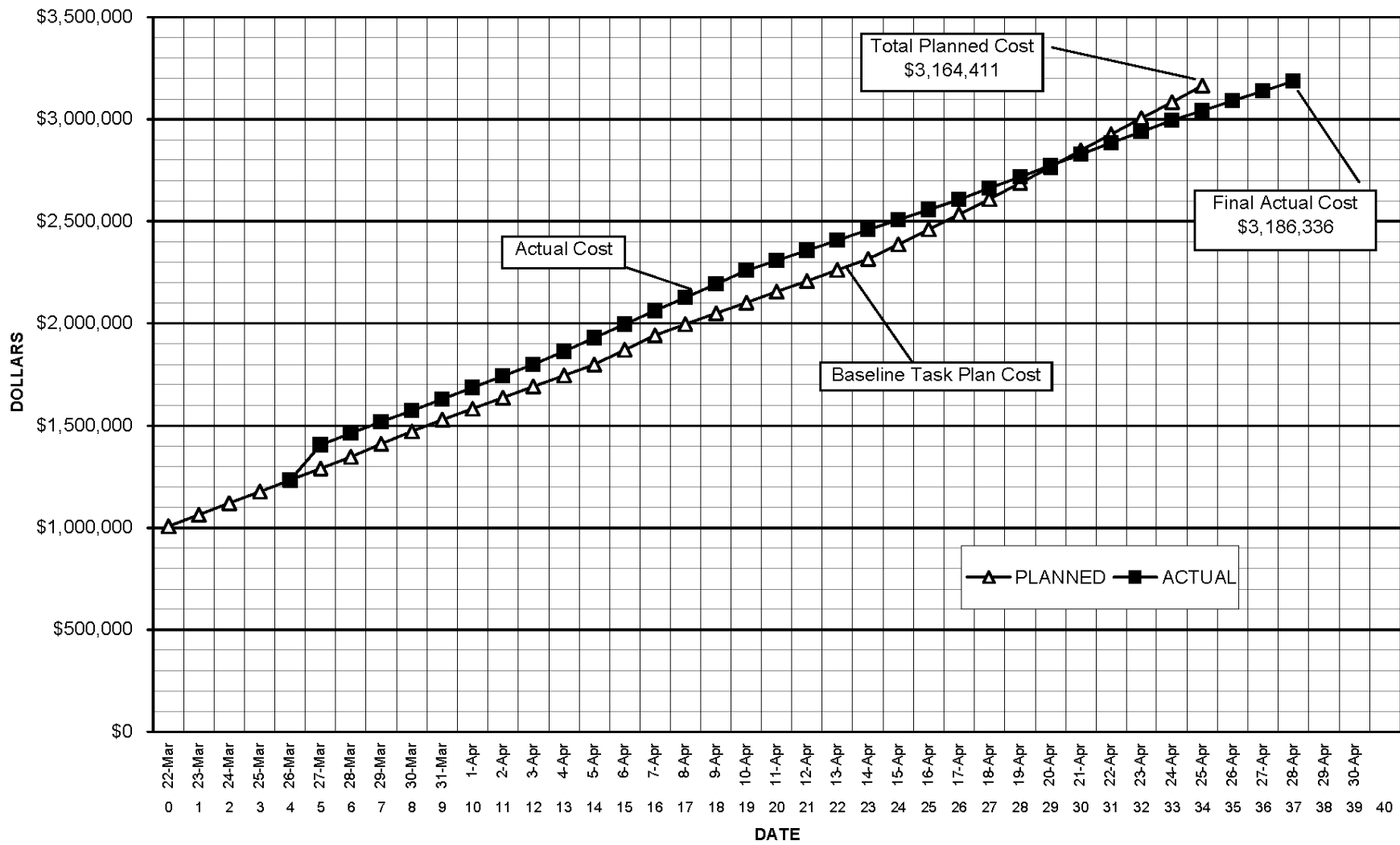


Figure 8-2
Planned and Actual Cost of Constructing Well ER-12-3

This page intentionally left blank.

9.0 Summary, Recommendations, and Lessons Learned

9.1 Summary

Main hole drilling at Well ER-12-3 commenced on March 26, 2005, and concluded on April 23, 2005, at a total drilled depth of 1,496.0 m (4,908 ft). Other than delays caused by weather and mechanical problems with the rig, no significant problems were encountered during drilling. The primary hydrogeologic target zone (the LCA) was encountered, and the main completion string was installed as planned. A piezometer consisting of a string of 2³/₈-in. slotted, carbon-steel tubing was placed in the annular space between the 13³/₈-in. surface casing and the borehole wall to a depth of 467.1 m (1,532.5 ft) to allow monitoring of perched water within the TCU identified during drilling.

Geologic data collected during drilling included composite drill cuttings samples collected every 3 m (10 ft) from 6.1 m (20 ft) to TD. In addition, 35 sidewall core samples were collected in the interval 121.9 to 1,453.9 m (400 to 4,770 ft). Geophysical logging was conducted in the upper portion of the borehole before installation of the surface casing, and in the lower portion prior to 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.

Well ER-12-3 is collared in moderately welded Rainier Mesa Tuff, and penetrated 673.6 m (2,210 ft) of Tertiary volcanic rocks consisting largely of bedded and nonwelded tuff. Below the volcanic rocks the borehole penetrated 822.4 m (2,698 ft) of Paleozoic carbonate rocks before reaching TD at 1,496.0 m (4,908 ft). Precambrian quartzite that forms the upper plate of the Belted Range thrust fault was not encountered as expected above the carbonate rocks. The pre-development water level in the well was measured within the LCA at 949.1 m (3,113.7 ft) on June 11, 2005. Throughout most of the drilling, tritium levels in the drilling fluid ranged from 0 to 2,161.6 pCi/L, which is at or below background levels for the field device in use. Other than a few elevated tritium readings that were found to be erroneous, no other radionuclides above background were encountered in the drilling fluids from Well ER-12-3.

9.2 Recommendations

The geologic data from the well should be integrated with the magnetotelluric survey of Rainier Mesa, and used as a “tie-point” for the survey. All the geologic and hydrologic data and interpretations from Well ER-12-3 should be integrated into the Rainier Mesa-Shoshone

Mountain hydrostratigraphic framework model. This will allow for more precise characterization of groundwater flow direction and velocity in the Rainier Mesa area.

9.3 *Lessons Learned*

The efficiency of drilling and constructing wells to obtain hydrogeologic data in support of the UGTA project continues to improve as experience is gained with each new well. Sometimes difficult drilling conditions are encountered and challenges are confronted. Two lessons learned during the construction of Well ER-12-3, the first well in the FY 2005 Rainier Mesa - Shoshone Mountain drilling initiative are described below.

- Snow and cold weather caused site access problems and other delays. In the future, drilling at high elevations in winter should be avoided if possible.
- A day's worth of logging data was accidentally deleted by the logging contractor, and the logs had to be re-run. Copies of the electronic files should be provided to BN and SNJV personnel as soon as possible following the completion of each log.

10.0 References

- Appenzeller-Wing, J., U.S. Department of Energy, National Nuclear Security Administration Nevada Site Office, 2005. Letter to T. H. Murphy, Nevada Division of Environmental Protection. Subject: "Well-Site Fluid Management Strategy, DOE NNSA/NSO UGTA Rainier Mesa-Shoshone Mountain Drilling Program, Nevada Test Site, Well ER-12-3." March 2, 2005. Las Vegas, NV.
- Bangerter, R. M., National Nuclear Security Administration Nevada Site Office, 2005. Verbal communication to P. K. Ortego, Bechtel Nevada. Subject: "Changes to Field Activity Work Plan D-002-001.05 for ER-12-3 Drilling and Completion." BN Record of Verbal Communication Number RVC-05-0002. March 25, 2005. Las Vegas, NV.
- Bechtel Nevada, 2004. "Underground Testing Area (UGTA) Project Health and Safety Plan (HASP)," Revision 1, December 2004. Las Vegas, NV.
- Bechtel Nevada, 2005. *Field Activity Work Package for Construction of Underground Test Area (UGTA) Investigation Well ER-12-3*. FAWP Number D-002-001.05, February 19, 2005. Las Vegas, NV.
- BN, see Bechtel Nevada.
- Cole, J. C., and P. H. Cashman, 1999. Structural Relationships of Pre-Tertiary Rocks in the Nevada Test Site Region, Southern Nevada. U.S. Geological Survey Professional Paper 1607.
- Cole, J. C., A. G. Harris, and R. R. Wahl, 1997. "Subcrop Geologic Map of Pre-Tertiary Rocks in the Yucca Flat and Northern Frenchman Flat Areas, Nevada Test Site, Southern Nevada." U.S. Geological Survey Open-File Report 97-678, scale 1:48,000. Denver, CO.
- DOE/NV, see U.S. Department of Energy.
- Gibbons, A. B., E. N. Hinrichs, W. R. Hansen, and R. W. Lemke, 1963. Geology of the Rainier Mesa Quadrangle, Nye County, Nevada. U.S. Geological Survey Map GQ-215.
- Harris, A. G., 2005. Written communication prepared for Stoller-Navarro Joint Venture, Las Vegas, NV. Subject: "Report on Referred Fossils, Well ER-12-3, Nye County, Nevada." September 23, 2005.
- Laczniak, R. J., J. C. Cole, D. A. Sawyer, and D. A. Trudeau, 1996. *Summary of Hydrogeologic Controls on the Ground-water Flow at the Nevada Test Site, Nye County, Nevada*. U.S. Geological Survey Water-Resources Investigation Report 96-4109. Carson City, NV.

- Leavitt, A. J., Fronterra Integrated Geosciences, 2005. Written communication prepared for Bechtel Nevada, Las Vegas, NV. Subject: "Formation Image Interpretation Report, Well ER-12-3, Nevada Test Site, Nye County Nevada, Structure Interpretation in the Paleozoic Carbonate Rocks."
- Lyles, B. F., Desert Research Institute, 2005. Written communication: Subject: "Preliminary Hydrophysical Logging Interpretations (Well ER-12-3), April 26, 2005." Las Vegas, NV.
- Naeser, C. W., and F. Maldonado, 1981. *Fission-Track Dating of the Climax and Gold Meadows Stocks, Nye County, Nevada*. In: Short Contributions to Geochronology: U.S. Geological Survey Professional Paper 1199E, pp. 45-47.
- NARA, see National Archives and Records Administration.
- National Archives and Records Administration, 1973. *National Geodetic Vertical Datum of 1929 (NGVD 29)*. Federal Register Notice, Document 73-9694, v. 38, n. 94, May 16, 1973.
- National Archives and Records Administration, 1989. *North American Datum of 1983 (NAD 83)*. Federal Register Notice, Document 89-14076, v. 54, n., 113, May 14, 1989.
- Nevada Bureau of Mines and Geology, 1997. County Digital Geologic Mapping Project - Final Report. Open-File Report 97-1, scale 1:250,000.
- Prothro, L. B., Bechtel Nevada, 2005a. Written communication: Email dated July 25, 2005. Subject: "Preliminary Geology and Hydrogeology of Well ER-12-3." Las Vegas, NV.
- Prothro, L. B., 2005b. *Mineralogic Zonation Within the Tuff Confining Unit, Yucca Flat, Nevada Test Site*. DOE/NV/11718--995. Bechtel Nevada, Las Vegas, NV.
- Sawyer, D. A., J. J. Fleck, M. A. Lanphere, R. G. Warren, and D. E. Broxton, 1994. "Episodic Caldera Volcanism in the Miocene Southwest Nevada Volcanic Field: Revised Stratigraphic Caldera Framework, $^{40}\text{Ar}/^{39}\text{Ar}$ Geochronology, and Implications for Magmatism and Extension." Geological Society of America Bulletin, v. 67, n. 10, p. 1,304-1,318.
- Slate, J. L., M. E. Berry, P. D. Rowley, C. J. Fridrich, K. S. Morgan, J. B. Workman, O. D. Young, G. L. Dixon, V. S. Williams, E. H. McKee, D. A. Ponce, T. G. Hildenbrand, WC Swadley, S. C. Lundstrom, E. B. Ekren, R. G. Warren, J. C. Cole, R. J. Fleck, M. A. Lanphere, D. A. Sawyer, S. A. Minor, D. J. Grunwald, R. J. Laczniak, C. M. Menges, J. C. Yount, and A. S. Jayko, 1999. *Digital Geologic Map of the Map of the Nevada Test Site and Vicinity, Nye, Lincoln, and Clark Counties, Nevada and Inyo County, California*. U.S. Geological Survey Open-File Report 99B554BA, scale 1:120,000.
- SNJV, see Stoller-Navarro Joint Venture.
- Stoller-Navarro Joint Venture, 2004. *Value of Information Analysis for Corrective Action Unit 99: Rainier Mesa/Shoshone Mountain, Nevada Test Site, Nevada*. S-N/99205--031. Las Vegas, NV.

- Stoller-Navarro Joint Venture, 2005a. *Rainier Mesa-Shoshone Mountain Hydrogeologic Investigation Wells Drilling and Completion Criteria*, S-N/99205--038. Las Vegas, NV.
- Stoller-Navarro Joint Venture, 2005b. Written communication prepared for NNSA/NSO. Subject: "Rainier Mesa ER-12-3, Well Data Report," September 2005. Las Vegas, NV.
- U.S. Coast and Geodetic Survey, 1927. *Annual Report to the Director*.
- U.S. Department of Energy, Nevada Operations Office, 2002a. Attachment 1, "Fluid Management Plan for the Underground Test Area Project, Rev. 3," DOE/NV--370. Las Vegas, NV.
- U.S. Department of Energy, Nevada Operations Office, 2002b. Underground Test Area (UGTA) Waste Management Plan. DOE/NV--343-Rev. 2. Las Vegas, NV.
- Winograd, I. J. and William Thordarson, 1975. *Hydrogeologic and Hydrochemical Framework, South-Central Great Basin, Nevada-California, with Special Reference to the Nevada Test Site*. U.S. Geological Survey Professional Paper 712-C, 126 pp. Washington, DC.
- WoldeGabriel, G., Los Alamos National Laboratory, 2006a.. Written communication: Email to S. Drellack, Bechtel Nevada, dated February 8, 2006. Subject: "Re: TCM Model Area," including XRD and XRF results for RM-SM Samples. Los Alamos, New Mexico.
- WoldeGabriel, G., Los Alamos National Laboratory, 2006b. Written communication: Email to L. Prothro, Bechtel Nevada, dated February 27, 2006. Subject: "Re: Petrography Results," including petrographic results for RM-SM Samples. Los Alamos, New Mexico.

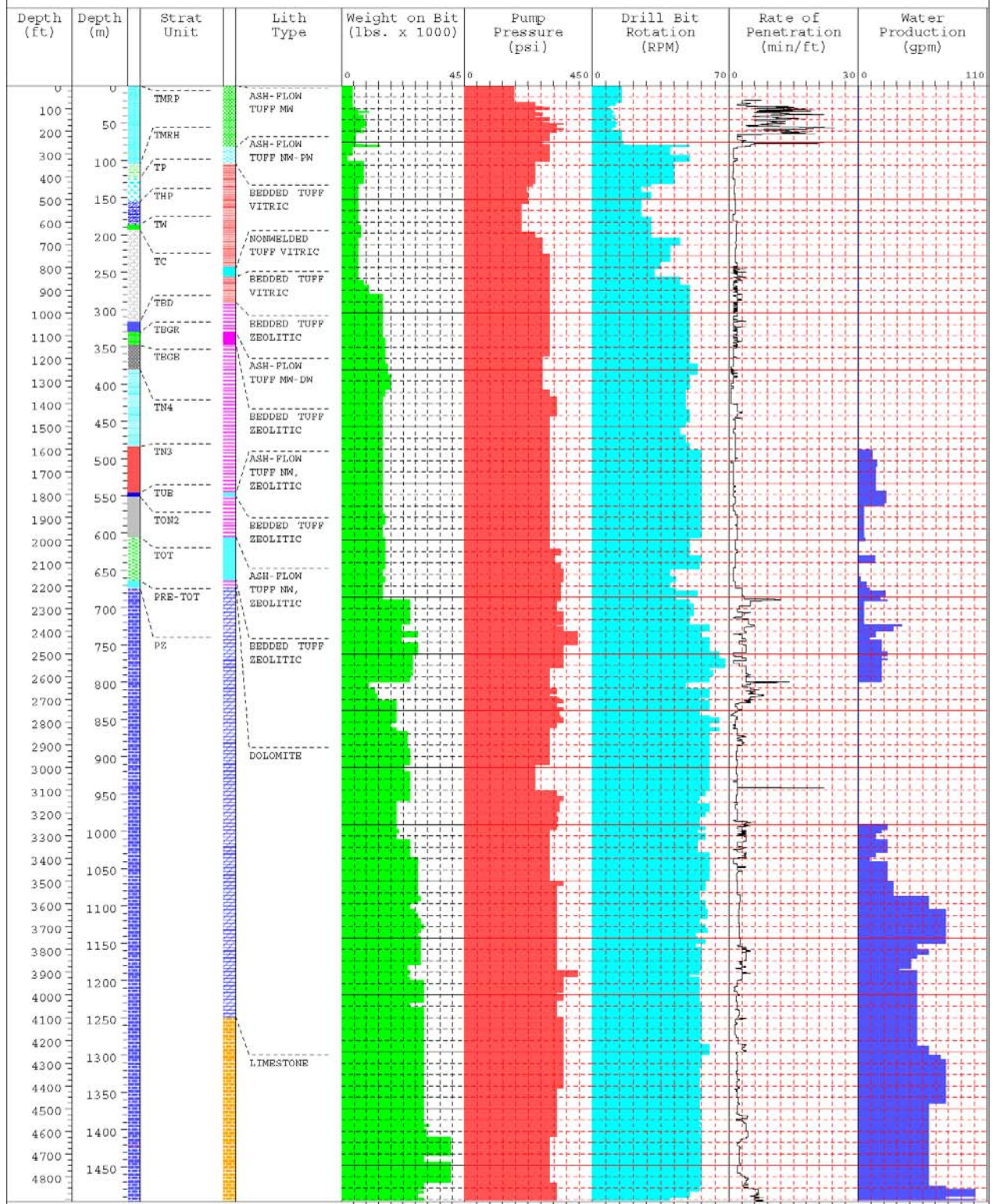
This page intentionally left blank.

Appendix A Drilling Data

- A-1 Drilling Parameter Log for Well ER-12-3**
- A-2 Tubing and Casing Data for Well ER-12-3**
- A-3 Well ER-12-3 Drilling Fluids and Cement Composition**

Appendix A-1
Drilling Parameter Log for Well ER-12-3

Well Name: ER-12-3	Rainier Mesa/Shoshone Mountain Drilling Program		Northing: 4,116,789.7 m
Date: 2/2/06	Start Date: 03/26/05	Stop Date: 04/28/05	Easting: 569,668.4 m
Environmental Contractor: UGTA/SNJV	Project No: UG05-630		Surface Elevation: 7,390.8 ft
Drilling Contractor: UDI	Drilling Method: Air Foam Rotary	Geologist: J. Wurtz	Drilled Depth: 4,908 ft



This page intentionally left blank.

Appendix A-2
Tubing and Casing Data for Well ER-12-3

**Table A-2
Tubing and Casing Data for Well ER-12-3**

Casing	Depth Interval meters (feet)	Type	Grade	Outside Diameter centimeters (inches)	Inside Diameter centimeters (inches)	Wall Thickness centimeters (inches)	Weight per foot (pounds)
Conductor	0 to 16.5 (0 to 54)	Carbon Steel	N/A	76.2 (30)	74.295 (29.0)	1.27 (0.5)	150
Intermediate	0 to 539.7 (0 to 1,770.8)	Carbon Steel	J-55	33.97 (13.375)	31.79 (12.615)	0.97 (0.38)	54.5
Intermediate	539.7 to 743.1 (1,770.8 to 2,438.0)	Carbon Steel	J-55	33.97 (13.375)	31.79 (12.515)	1.09 (0.43)	61
Completion	0 to 1,067.6 (0 to 3,502.8)	Carbon Steel	K-55	19.37 (7.625)	17.70 (6.969)	0.84 (0.33)	26.4
Completion	1,068.4 to 1,487.4 (3,505.1 to 4,880.0)	Stainless Steel	L304	13.97 (5.500)	12.82 (5.047)	0.58 (0.227)	14.6
Piezometer	0 to 467.1 (0 to 1,532.5)	Carbon Steel	J-55	6.03 (2.375)	5.07 (1.995)	0.48 (0.19)	4.6

This page intentionally left blank.

Appendix A-3
Well ER-12-3 Drilling Fluids and Cement Composition

**Table A-3-1
Drilling Fluids Used in Well ER-12-3**

Typical Air-Foam/Polymer Mix	Typical Bentonite Mud Mix ^a
56.8 to 94.6 liters (15 to 25 gallons) Acrylafoam ^{® a} 7.6 liters (2 gallons) Acrylavis ^{® b} 0.5 to 1.5 liters of lithium bromide per 7,949 liters (50 barrels) water	60 to 70 viscosity bentonite ^c

a Acrylafoam [®] foaming agent is a product of Hinkle Chemical Corp.

b Acrylavis [®] polymer additive is a product of Cytec Manufacturing Corp.

c The bentonite gel additive was supplied by Western Clay.

NOTES:

1. All water used to mix drilling fluids for Well ER-12-3 came from Water Well 8 in Area 18.
2. A concentrated solution of lithium bromide was added to all introduced fluids to make up a final concentration of 10 to 60 milligrams per liter.

**Table A-3-2
Well ER-12-3 Cement Composition**

Cement Composition	30-inch Conductor Casing		13 ⁹ / ₁₆ -inch Intermediate Casing	
	Interval	Amount	Interval	Amount
Type II with aggregate	0 to 15.1 m ^a (0 to 49.6 ft ^b)	18.3 m ³ ^c (648 ft ³) ^d	Not used	None
Type II neat	15.1 to 16.8 m (49.6 to 55.0 ft)	2.3 m ³ (81 ft ³)	673.6 to 745.8 m (2,210 to 2,447 ft)	14.2 m ³ (500 ft ³)

a meter(s) b foot (feet) c cubic meters d cubic feet

This page intentionally left blank.

Appendix B
Well ER-12-3 Fluid Management Data

Table B-1 Well ER-12-3 Fluid Disposition Reporting Form

Site Identification: ER-12-3

Site Location: Nevada Test Site

Approximate Site Coordinates: N: 4,116,592.2 m E: 569,748.3 m

Well Classification: ER Hydrogeologic Investigation Well

Project Number: UG05-630

Report Date: August 2005

NNSA/NSO Project Manager: Bob Bangerter

SNJV Project Manager: John McCord

SNJV Site Representative: Jeff Wurtz

SNJV Waste Coordinator: Dave Schrock

Well 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) ^c	Other ^d (m ³)	Fluid Quality Objectives Met?
	From	To				Solids ^b	Liquids	Solids	Liquids			
Phase I: Vadose-Zone Drilling	3/26/05	4/12/05	12	951	1,100	223	141	0	0	0	NA	Yes
Phase I: Saturated-Zone Drilling	4/12/05	4/23/05	7	545	269	62	448	0	0	638	NA	Yes
Phase II: Initial Well Development	Pending	Pending	-	-	-	-	-	-	-	-	-	-
Phase II: Aquifer Testing	Pending	Pending	-	-	-	-	-	-	-	-	-	-
Phase II: Final Development	Pending	Pending	-	-	-	-	-	-	-	-	-	-
Cumulative Production Totals to Date:			19	1,496	1,369	285	589	0	0	638	NA	Yes

^aOperational days refer to the number of days that fluids were produced during at least part (>3 hours) of one shift.

^bSolids volume estimates include rock bulking factor of 1.5.

^cGround surface discharge.

^dOther 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.

m = Meters m³ = Cubic Meters NA = Not Applicable

Total Facility Capacities (at 7 ft fluid level): Sump #1 = 1,018 m³ Sump #2 = 732 m³

Infiltration Area (assuming very low/no infiltration) = NA m³

Remaining Facility Capacity (Approximate) as of 04/23/2005: Sump #1 = 0 m³ (0%) Sump #2 = 732 m³ (100%)

Current Average Tritium = (Natural Background) pCi/L

SNJV Authorizing Signature/Date

 9-29-05

Appendix C
Detailed Lithologic Log for Well ER-12-3

Detailed Lithologic Log for Well ER-12-3
 Logged by Lance Prothro, Bechtel Nevada
 October 2005

Depth Interval meters (feet)	Thickness meters (feet)	Sample Type ^a	Depth of Analytical Samples ^b meters (feet)	Lithologic Description ^c	Stratigraphic Unit
0 - 82.3 (0 - 270)	82.3 (270)	DA	None	Moderately Welded Ash-Flow Tuff: Grayish-red (10R 4/2); devitrified; common flattened pumice; minor felsic phenocrysts of quartz and feldspar; rare biotite; rare lithic fragments.	mafic-poor Rainier Mesa Tuff
82.3 - 87.8 (270 - 288)	5.5 (18)	DA	None	Partially Welded Ash-Flow Tuff: Pale-red (10R 6/2); devitrified; minor partially flattened pumice; common felsic phenocrysts of quartz and feldspar; rare biotite; rare lithic fragments.	
87.8 - 105.5 (288 - 346)	17.7 (58)	DA	None	Nonwelded Ash-Flow Tuff: Pale-yellowish-brown (10YR 6/2); vitric; common pumice; common felsic phenocrysts of quartz and feldspar; rare biotite; rare lithic fragments.	
105.5 - 123.7 (346 - 406)	18.3 (60)	DB1, SC	None	Bedded Tuff: Moderate-yellowish-brown (5YR 5/4); vitric; minor to common pumice; minor to common felsic phenocrysts of quartz and feldspar; common very small mafic minerals of biotite and hornblende; rare to minor lithic fragments. Sidewall core sample at 121.9 m (400 ft) is vitric, contains quartz and biotite, and has conspicuous sphene.	Tuff of Holmes Road
123.7 - 155.4 (406 - 510)	31.7 (104)	DB1, DB4	None	Bedded Tuff: Drill cuttings are poor quality consisting of mixtures of various tuffaceous beds and hard components (e.g., lithic and vitric pumice fragments), including considerable amounts of material from higher horizons. Density log indicates interval is not welded. Resistivity log indicates interval is vitric and bedded. The lack of fragments with intact matrix is characteristic of drill cuttings samples of vitric nonwelded tuffs. Lithology is consistent with nearby core hole UE-12n#6. Lower contact is based on correlation with UE-12n#6.	Paintbrush Group, undivided

C-1

Lithologic Log for Well ER-12-3

Depth Interval meters (feet)	Thickness meters (feet)	Sample Type ^a	Depth of Analytical Samples ^b meters (feet)	Lithologic Description ^c	Stratigraphic Unit
155.4 - 186.2 (510 - 611)	30.8 (101)	DB4, SC	None	Bedded Tuff: Drill cuttings are poor quality. Sidewall sample at 182.9 m (600 ft) is very-light-gray (N8), vitric with rare to minor felsic phenocrysts of feldspar and quartz, rare biotite, and rare lithic fragments. Contacts are based on geophysical logs.	mafic-poor Calico Hills Formation
186.2 - 193.9 (611 - 636)	7.6 (25)	DB1, DB4	None	Bedded Tuff: White (N9); vitric; minor white (N9) pumice; abundant feldspar phenocrysts; very abundant mafic minerals of biotite and orthopyroxene.	Wahmonie Formation
193.9 - 218.2 (636 - 716)	24.4 (80)	DA	None	Bedded Tuff: Moderate-yellowish-brown (10YR 5/4); vitric to partially argillic; common white (N9) pumice, many of which swell and disintegrate when moistened; common to abundant felsic phenocrysts of feldspar and lesser quartz; minor to common mafic minerals of biotite and much less hornblende and clinopyroxene; rare lithic fragments. Conspicuous fragments of very-fine-grained, aphyric, ash that disintegrates when moistened are common in the lower portion of interval.	Crater Flat Group, undivided
218.2 - 243.8 (716 - 800)	25.6 (84)	DB1, DB4	None	Bedded Tuff: Drill cuttings are poor quality, consisting of mixtures of various tuffaceous fragments and hard components including vitric fragments of nonwelded tuff and pumice, and devitrified volcanic lithic fragments. Density and resistivity logs indicate interval is composed of vitric bedded tuff, which correlates well with nearby core hole UE-12n#6.	
243.8 - 256.0 (800 - 840)	12.2 (40)	DA	None	Nonwelded Ash-Flow Tuff: Pale-red (10R 6/2); vitric; rare pumice; rare to minor felsic phenocrysts of feldspar and lesser quartz; minor to common biotite; rare lithic fragments.	

C-2

Depth Interval meters (feet)	Thickness meters (feet)	Sample Type ^a	Depth of Analytical Samples ^b meters (feet)	Lithologic Description ^c	Stratigraphic Unit
256.0 - 279.5 (840 - 917)	23.5 (77)	DA	265.2 (870)	Bedded Tuff: Grayish-orange-pink (5YR 7/2) and very-pale-orange (10YR 8/2); mostly vitric, much less zeolitic; rare pumice; rare to minor felsic phenocrysts of quartz and feldspar; common biotite; rare lithic fragments in upper part, becoming conspicuous as loose matrix-coated fragments at base of interval.	Crater Flat Group, undivided
279.5 - 295.7 (917 - 970)	16.2 (53)	DA, SC	286.5 (940)	Bedded Tuff: Pale-yellowish-brown (10YR 6/2) and moderate-yellowish-brown (10YR 5/4); mostly zeolitic, much less vitric, becoming pervasively zeolitic below 291.1 m (955 ft); minor pumice; minor to common felsic phenocrysts of feldspar and quartz; common mafic minerals of biotite and lesser hornblende; rare to minor lithic fragments.	
295.7 - 317.0 (970 - 1,040)	21.3 (70)	DA	304.8 (1,000)	Bedded Tuff: Moderate-yellowish-brown (10YR 5/4) to moderate-brown (5YR 4/4); zeolitic; very abundant white (N1) to grayish-yellow (5Y 8/4) pumice; minor to common felsic phenocrysts of quartz and feldspar; minor mafic minerals of biotite and lesser hornblende with mafic mineral abundance increasing to common near base of interval; rare to minor lithic fragments.	
317.0 - 330.7 (1,040 - 1,085)	13.7 (45)	DA	None	Bedded Tuff: Grayish-yellow (5Y 8/4); zeolitic; minor pumice; rare to minor feldspar phenocrysts (no quartz); mafic minerals are conspicuously absent; minor grayish-red (10R 4/2) to very-dusky-red (10R 2/2) lithic fragments.	Dead Horse Flat Formation
330.7 - 348.4 (1,085 - 1,143)	17.7 (58)	DA	None	Moderately to Densely Welded Ash-Flow Tuff: Moderate-yellowish-brown (10YR 5/4); devitrified; minor to common olive-gray (5Y 3/2) highly flattened pumice; minor to common feldspar phenocrysts (no quartz); mafic minerals are conspicuously absent; no lithic fragments observed.	crystal-rich Grouse Canyon Tuff

Lithologic Log for Well ER-12-3

Depth Interval meters (feet)	Thickness meters (feet)	Sample Type ^a	Depth of Analytical Samples ^b meters (feet)	Lithologic Description ^c	Stratigraphic Unit
348.4 - 381.0 (1,143 - 1,250)	32.6 (107)	DA	None	Bedded Tuff: Dusky-yellow (5Y 6/4); zeolitic; trace of pumice; conspicuously aphyric with no felsic phenocrysts or mafic minerals present; rare lithic fragments.	bedded Grouse Canyon Tuff
381.0 - 412.7 (1,250 - 1,354)	31.7 (104)	DA	None	Bedded Tuff: Yellowish-gray (5Y 8/1) and pale-reddish-brown (10R 5/4); zeolitic; minor to common white (N9) and pale-greenish-yellow (10Y 8/2) pumice; common feldspar phenocrysts; abundant mafic minerals of biotite and lesser hornblende; rare lithic fragments. Borehole image log indicates bedding strikes N84°E and dips 18° NW.	beds 4K Tunnel Formation
412.7 - 423.7 (1,354 - 1,390)	11.0 (36)	DA	None	Bedded Tuff: Moderate-reddish-brown (10R 4/6); zeolitic; common moderate-orange-pink (5YR 8/4) pumice; rare feldspar phenocrysts; rare biotite; rare lithic fragments. Borehole image log indicates bedding strikes N73°W and dips 19° NE.	beds 4J Tunnel Formation
423.7 - 438.3 (1,390 - 1,438)	14.6 (48)	DA, SC	None	Bedded Tuff: White (N9), yellowish-gray (5Y8/1), and pale-greenish-yellow (10Y 8/2); zeolitic; rare pumice; rare feldspar phenocrysts; minor biotite; rare lithic fragments. Sidewall core at 426.7 m (1,400 ft) is zeolitic with minor feldspar phenocrysts of feldspar and quartz, and rare biotite. Borehole image log indicates bedding strikes N86°W and dips 20° NE.	beds 4H Tunnel Formation

C-4

Depth Interval meters (feet)	Thickness meters (feet)	Sample Type ^a	Depth of Analytical Samples ^b meters (feet)	Lithologic Description ^c	Stratigraphic Unit
438.3 - 442.0 (1,438 - 1,450)	3.7 (12)	DA	None	Bedded Tuff: Similar to above interval but with a conspicuous mottled grayish-orange (10YR 7/4) and moderate-reddish-brown (10R 4/6) very fine-grained zeolitic ash bed at base. This ash bed is present in nearby core hole UE-12n#6 as well as in core holes in Yucca Flat, and is considered a marker bed for the base of Tn4G. Borehole image log indicates bedding strikes N84°W and dips 16° NE.	beds 4G Tunnel Formation
442.0 - 484.0 (1,450 - 1,588)	42.1 (138)	DA	None	Bedded Tuff: Mostly grayish-yellow (5Y 8/4), lesser moderate-reddish-brown (10R 4/6); zeolitic; rare to common pumice; minor to common felsic phenocrysts of feldspar and quartz; rare to minor biotite; minor lithic fragments. Borehole image log indicates bedding strikes N85°W and dips 15° NE.	beds 4A - F Tunnel Formation
484.0 - 502.3 (1,588 - 1,648)	18.3 (60)	DA	None	Bedded Tuff: Moderate-reddish-brown (10R 4/6), moderate-orange-pink (10R 7/4), and grayish-yellow (5Y 8/4); zeolitic; common to abundant pumice; rare to minor felsic phenocrysts of feldspar and quartz; rare biotite; minor lithic fragments. Borehole image log indicates bedding strikes N76°E and dips 12° NW.	beds 3D Tunnel Formation
502.3 - 526.7 (1,648 - 1,728)	24.4 (80)	DA	None	Bedded Tuff: Grayish-yellow (5Y 8/4); zeolitic; rare pumice; rare felsic phenocrysts of feldspar and quartz; minor biotite; minor lithic fragments. Borehole image log indicates bedding strikes N79°E and dips 16° NW.	beds 3BC Tunnel Formation

Lithologic Log for Well ER-12-3

Depth Interval meters (feet)	Thickness meters (feet)	Sample Type ^a	Depth of Analytical Samples ^b meters (feet)	Lithologic Description ^c	Stratigraphic Unit
526.7 - 546.2 (1,728 - 1,792)	19.5 (64)	DA	None	<p>Bedded Tuff: Conspicuously, moderate-reddish-brown (10R 4/6); zeolitic; common pumice; common to abundant felsic phenocrysts of quartz and feldspar; abundant biotite; minor lithic fragments.</p> <p>Borehole image log indicates bedding strikes N86°E and dips 12° NW.</p>	beds 3A Tunnel Formation
546.2 - 551.4 (1,792 - 1,809)	5.2 (17)	DA, SC	None	<p>Nonwelded Ash-Flow Tuff: Dusky-yellow (5Y 6/4); zeolitic; common to abundant pumice; rare felsic phenocrysts of quartz and feldspar; mafic minerals are conspicuously absent; rare lithic fragments. Sidewall core at 548.6 m (1,800 ft) is moderate-yellowish-brown (10YR 5/4) and moderate-reddish-brown (10R 4/6), zeolitic, with feldspar and quartz, but no biotite.</p> <p>Borehole image log indicates bedding strikes N28°E and dips 10° NW.</p>	Tub Spring Tuff
551.4 - 605.3 (1,809 - 1,986)	53.9 (177)	DA	None	<p>Bedded Tuff: Grayish-yellow (5Y 8/4), light-brown (5YR 6/4), and pale-red (10R 6/2); zeolitic; common to abundant pumice; rare felsic phenocrysts of feldspar and quartz; minor to common biotite; rare to minor lithic fragments.</p> <p>Borehole image log indicates bedding strikes N88°E and dips 16° NW.</p>	tunnel bed 2

C-6

Lithologic Log for Well ER-12-3

Depth Interval meters (feet)	Thickness meters (feet)	Sample Type ^a	Depth of Analytical Samples ^b meters (feet)	Lithologic Description ^c	Stratigraphic Unit
605.3 - 664.2 (1,986 - 2,179)	58.8 (193)	DA, SC	621.8 (2,040) 640.1 (2,100)	<p>Nonwelded Ash-Flow Tuff: Grayish-yellow (5Y 8/4) in upper portion becoming dark-reddish-brown (10R 3/4) lower; quartzo-feldspathic with significant argillization; minor to common pumice; common to abundant felsic phenocrysts of feldspar and quartz; abundant to very abundant mafic minerals of biotite and lesser hornblende; rare lithic fragments.</p> <p>Borehole image log indicates bedding strikes N74°W and dips 17° NE.</p>	tuff of Twin Peaks
664.2 - 673.6 (2,179 - 2,210)	9.4 (31)	DA	673.6 (2,210)	<p>Bedded Tuff: Dusky-brown (5YR 2/2); argillic; rare pumice; common felsic phenocrysts of partially altered feldspar and lesser quartz; common biotite. Resistivity log indicates much of interval is argillic.</p>	pre-tuff of Twin Peaks volcanic rocks, undivided

C-7

Depth Interval meters (feet)	Thickness meters (feet)	Sample Type ^a	Depth of Analytical Samples ^b meters (feet)	Lithologic Description ^c	Stratigraphic Unit
673.6 - 1,167.4 (2,210 - 3,830)	493.8 (1,620)	DA, SC	716.3 (2,350) 823.0 (2,700) 914.4 (3,000) 1,036.3 (3,400) 1,143.0 (3,750)	<p>Dolomite: Black (N1) and medium-dark-gray (N4); well indurated; medium-crystalline; massive; weak fetid odor when broken; thin (<1 mm) fractures filled with dolomite and calcite are common but not conspicuous; rare loose fragments of coarsely-crystalline calcite and dolomite fracture-filling material.</p> <p>The upper contact strikes N 17° W and dips 33° NE based on analysis of the borehole image log.</p> <p>Conodont color alteration index values indicate rocks within interval reached maximum temperatures ranging from 300° C to 490° C. Heavy mineral fraction from biostratigraphic analyses include phlogopite and pyroxene. These data are indicative of low-grade metamorphism.</p> <p>Biostratigraphic analyses suggest a Silurian-Devonian age for rocks above approximately 853.4 m (2,800 ft) and a Middle to Late Ordovician age for rocks below approximately 853.4 m (2,800 ft).</p>	Paleozoic Carbonate Rocks, undivided
1,167.4 - 1,250.3 (3,830 - 4,102)	82.9 (272)	DA, SC	None	<p>Dolomite: Very-light-gray (N8) to medium-gray (N5), becoming grayish-black (N2) and moderate-orange-pink (10R 7/4) in lower portion; recrystallized and brecciated; moderately indurated; medium- to coarsely-crystalline; massive; darker-colored samples have weak fetid odor when broken; pinkish-color observed is probably iron-oxides associated with recrystallized breccia matrix. Conspicuously long (>3 mm) crystal aggregates are present but not common. Overall, interval appears to consist of dark-gray (N3) to grayish-black (N2) dolomite fragments similar to above interval within a lighter-gray and pinkish recrystallized dolomitic matrix.</p>	

Depth Interval meters (feet)	Thickness meters (feet)	Sample Type ^a	Depth of Analytical Samples ^b meters (feet)	Lithologic Description ^c	Stratigraphic Unit
1,250.3 - 1,496.0 (4,102 - 4,908) TD	245.7 (806)	DA, SC	1,258.8 (4,130) 1,295.4 (4,250) 1,341.1 (4,400) 1,408.2 (4,620) 1,417.3 (4,650) 1,463.0 (4,800)	Limestone: Medium-dark-gray (N4) above approximately 1,310.6 m (4,300 ft), becoming black (N1) lower; well indurated; medium- to finely-crystalline; massive; no fetid odor when broken; rare finely-crystalline aggregates of pyrite; thin (<1 mm) calcite-filled fractures are present but not particularly common; coarsely crystalline calcite fracture-fillings are common throughout. Fragments of dark-greenish-gray (5GY 4/1), non-calcareous, pyrite-bearing, soft (<5) material occurs in samples from 1,255.8 to 1,271.0 m (4,120 to 4,170 ft) and again around 1,280.2 m (4,200 ft). Interval is dolomitic in places particularly around 1,280.2 to 1,295.4 m (4,200 to 4,250 ft). Heavy mineral fraction from biostratigraphic analyses include amphibole and tremolite. No conodonts or other fossils were found as a result of biostratigraphic analyses.	Paleozoic Carbonate Rocks, undivided

C-9

- a **DA** = drill cuttings that represent lithologic character of interval; **DB1** = drill cuttings enriched in hard components; **DB4** = cuttings that are intimate mixtures of units, generally less than 50% of drill cuttings represent lithologic character of interval; **SC** = sidewall core.
- b Depth of lithologic samples selected for laboratory analyses. Laboratory analyses include biostratigraphy (depths in **bold**), petrography (polished thin section), mineralogy (electron microprobe and x-ray diffraction), and chemistry (x-ray fluorescence and wet chemical analysis for iron). Additional samples were selected for analysis from nearby core hole UE-12n #6. Results from these analyses will be integrated with data from correlative intervals in Well ER-12-3. See Table 3-2 of this report for additional information on laboratory analyses.
- c Descriptions are based mainly on visual examination of lithologic samples using a 10x- to 40x-zoom binocular microscope, and incorporating observations from geophysical logs and results of laboratory analyses. Colors describe wet sample color.
Abundance for felsic phenocrysts, pumice fragments, and lithic fragments: **trace** = only one or two individuals observed; **rare** = ≤ 1%; **minor** = 5%; **common** = 10%; **abundant** = 15%; **very abundant** ≥ 20%.
Abundance for mafic minerals: **trace** = only one or two individuals observed; **rare** = ≤ 0.05%; **minor** = 0.2%; **common** = 0.5%; **abundant** = 1%; **very abundant** = ≥ 2%.

This page intentionally left blank.

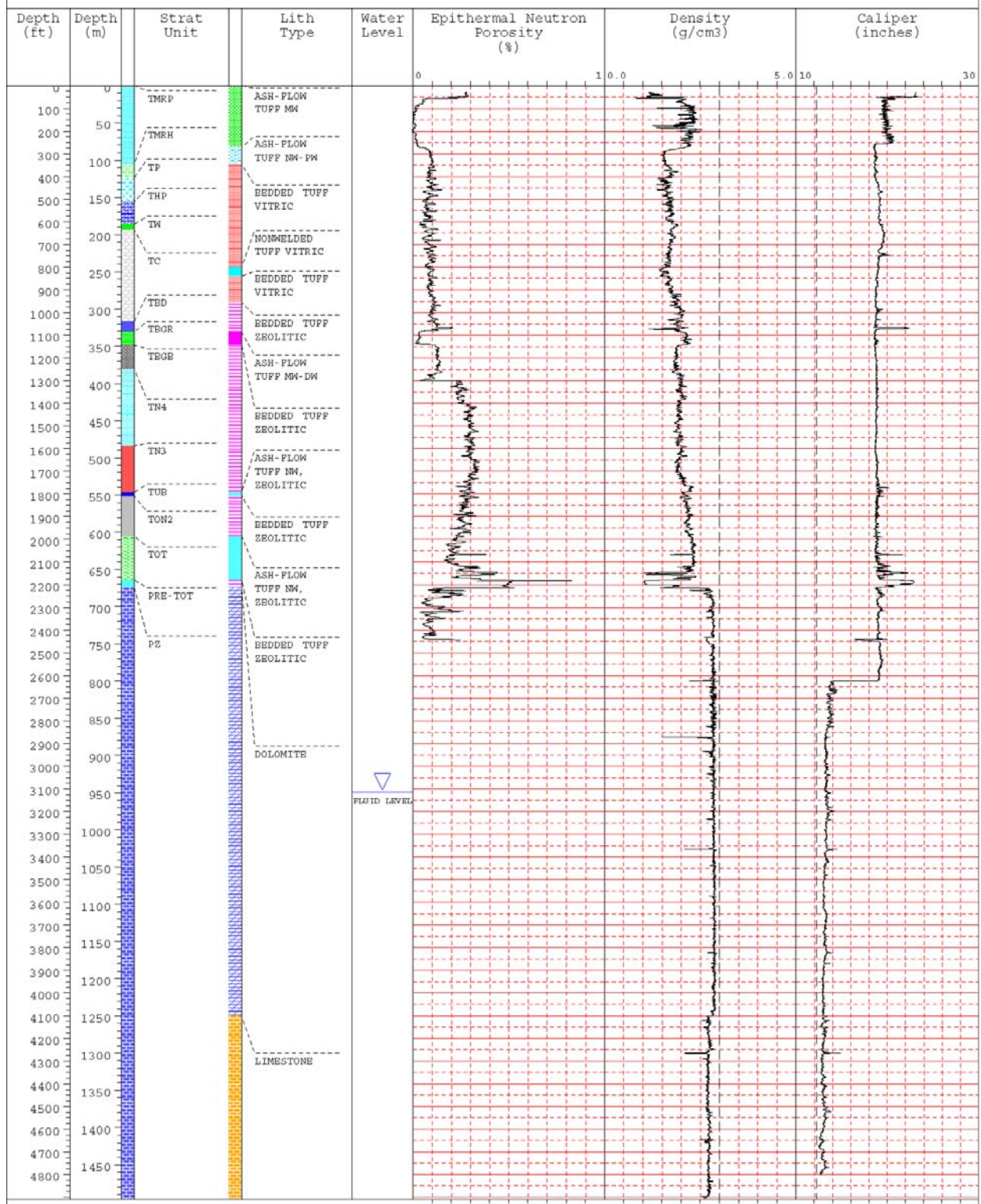
Appendix D
Geophysical Logs Run in Well ER-12-3

Appendix D contains unprocessed data presentations of selected geophysical logs run in Well ER-12-3. Table D-1 summarizes the logs presented. See Table 3-3 for more information.

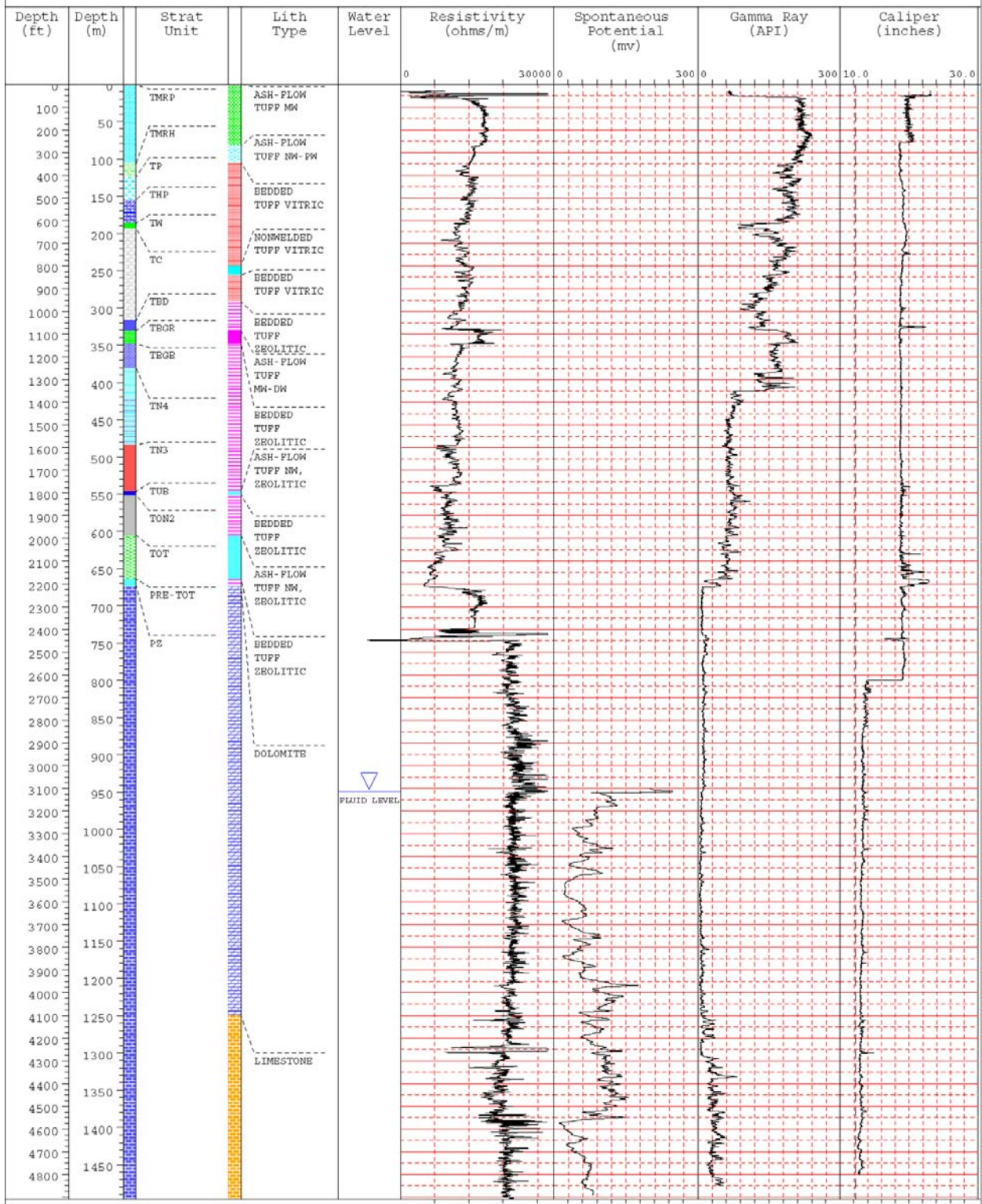
**Table D-1
Well ER-12-3 Geophysical Logs Presented**

Log Type	Run Number	Date	Log Interval	
			meters	feet
Caliper	CA6-1	04/03/2005	9.1 - 666.3	30 - 2,186
	CA6-4	04/25/2005	731.5 - 1,492.6	2,400 - 4,897
Epithermal Neutron (porosity)	DSEN-1	04/03/2005	9.1 - 666.0	30 - 2,185
	DSEN-2	04/07/2005	603.5 - 744.6	1,980 - 2,443
Density	SDL-1	04/03/2005	9.1 - 666.0	30 - 2,185
	SDL-3	04/24/2005	609.6 - 1,494.7	2,000 - 4,904
Induction (resistivity)	HRI-1	04/07/2005	16.5 - 750.7	54 - 2,463
	HRI-2	04/24/2005	731.5 - 1,492.6	2,400 - 4,897
Dual Laterolog (resistivity)	DLL-2	04/24/2005	944.9 - 1,490.8	3,100 - 4,891
Spontaneous Potential	SP-2	04/24/2005	944.9 - 1,490.8	3,100 - 4,891
Gamma Ray	GR-2	04/03/2005	9.1 - 666.	30 - 2,186
	GR-5	04/07/2005	603.5 - 744.6	1,980 - 2,443
	GR-11	04/24/2005	609.6 - 1,494.7	2,000 - 4,904
Full-wave Sonic - Delta T	FWS-1/GR-12	04/24/2005	944.9 - 1,491.7	3,100 - 4,894
Spectral Gamma Ray (potassium, thorium, uranium)	SGR-1	04/07/2005	365.8 - 741.6	1,200 - 2,433
	SGR-2	04/24/2005	731.5 - 1,482.2	2,400 - 4,863
Chemistry/Temperature	Chem-1/TL-4	04/26/2005	953.4 - 1,495.3	3,128 - 4,906
Thermal Flow Meter	HPFlow-1	04/26/2005	954.9 - 1,485.9	3,133 - 4,875

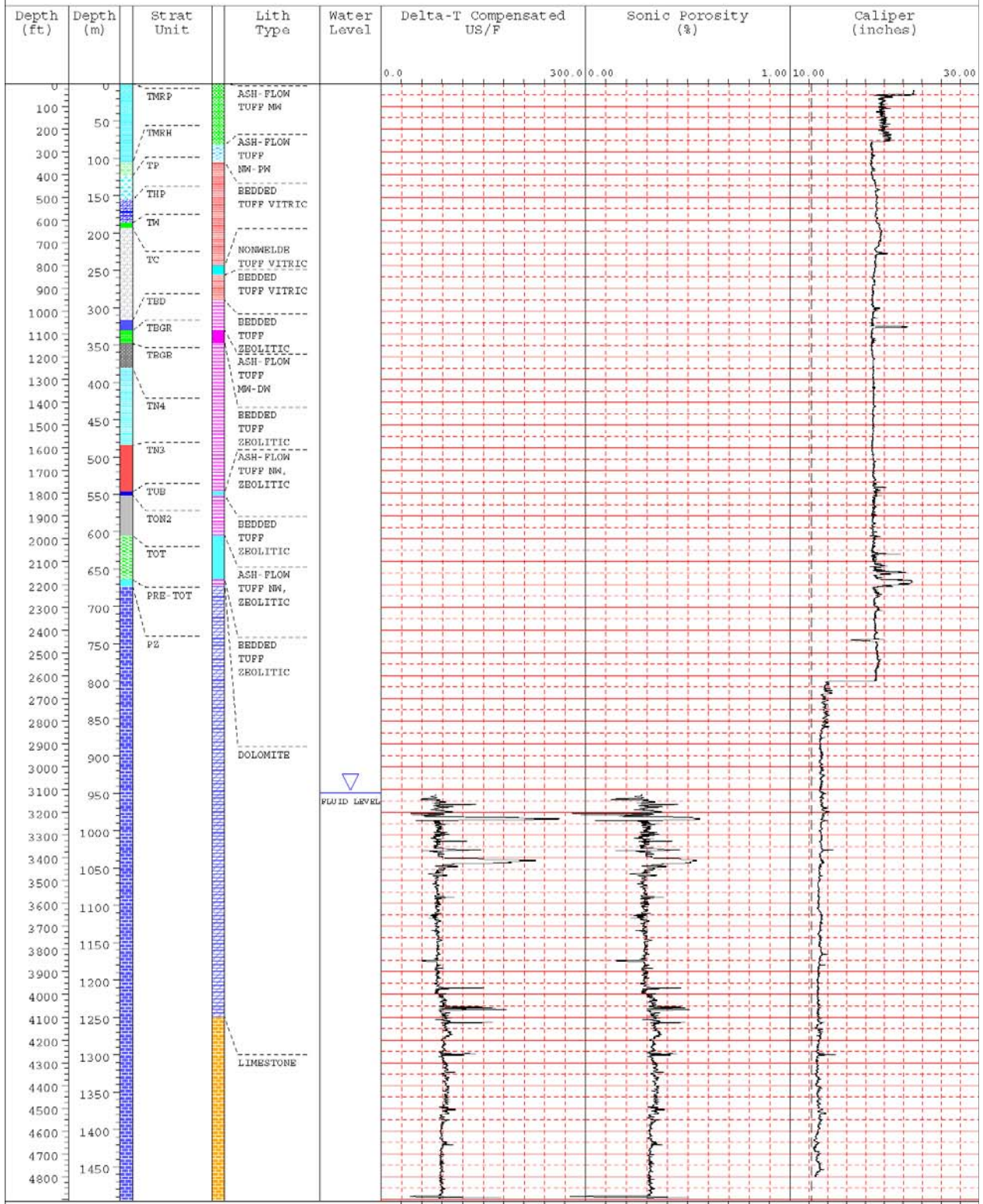
Well Name: ER-12-3	Rainier Mesa/Shoshone Mountain Drilling Program		Northing: 4,116,789.7 m
Date: 2/2/06	Start Date: 03/26/05	Stop Date: 04/28/05	Easting: 569,668.4 m
Environmental Contractor: UGTA/SNJV	Project No: UG05-630		Surface Elevation: 7,390.8 ft
Drilling Contractor: UDI	Drilling Method: Air Foam Rotary	Geologist: J. Wurtz	Drilled Depth: 4,908 ft



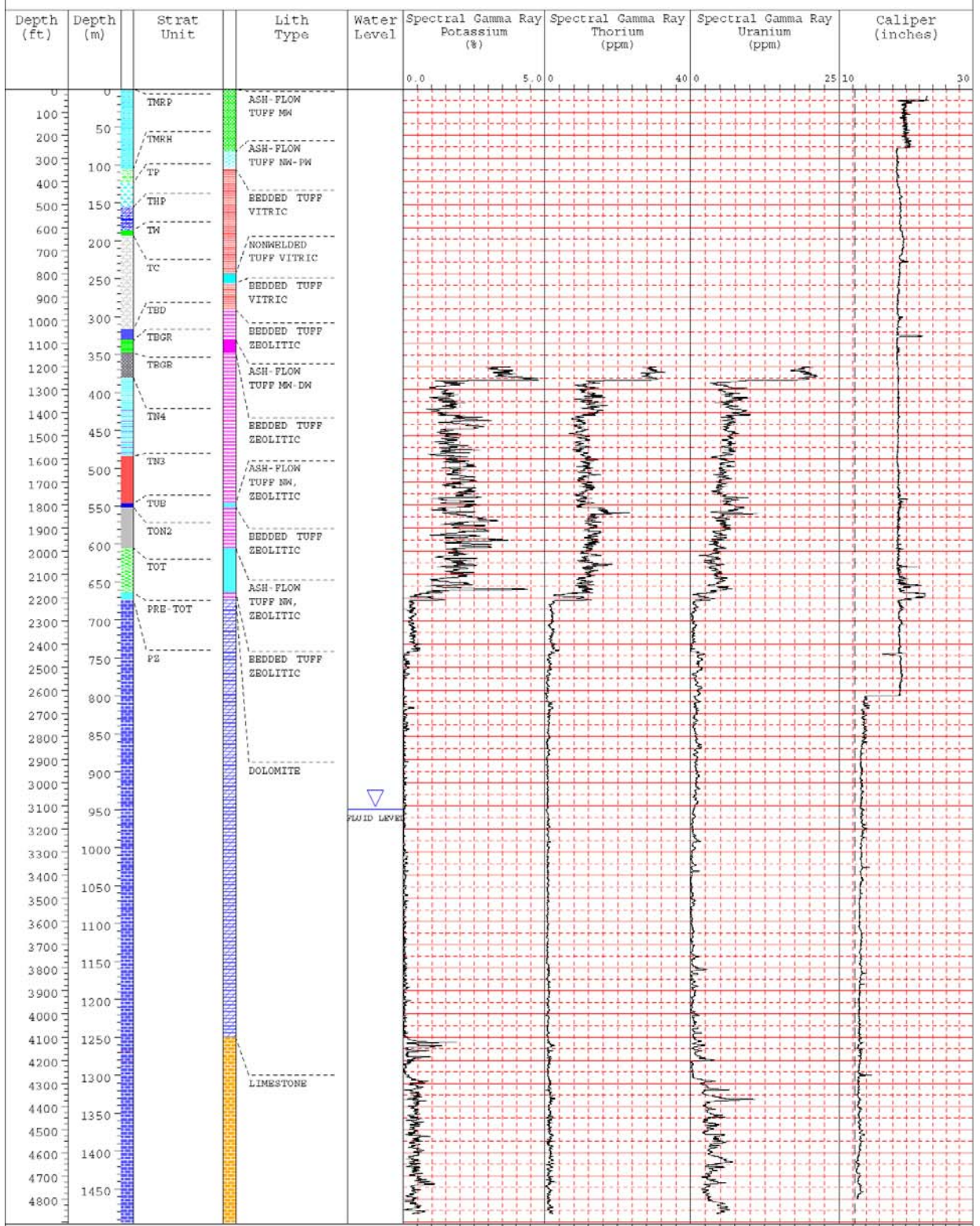
Well Name: ER-12-3	Rainier Mesa/Shoshone Mountain Drilling Program		Northing: 4,116,789.7 m
Date: 2/2/06	Start Date: 03/26/05	Stop Date: 04/28/05	Easting: 569,668.4 m
Environmental Contractor: UGTA/SNJV	Project No: UG05-630		Surface Elevation: 7,390.8 ft
Drilling Contractor: UDI	Drilling Method: Air Foam Rotary	Geologist: J. Wurtz	Drilled Depth: 4,908 ft



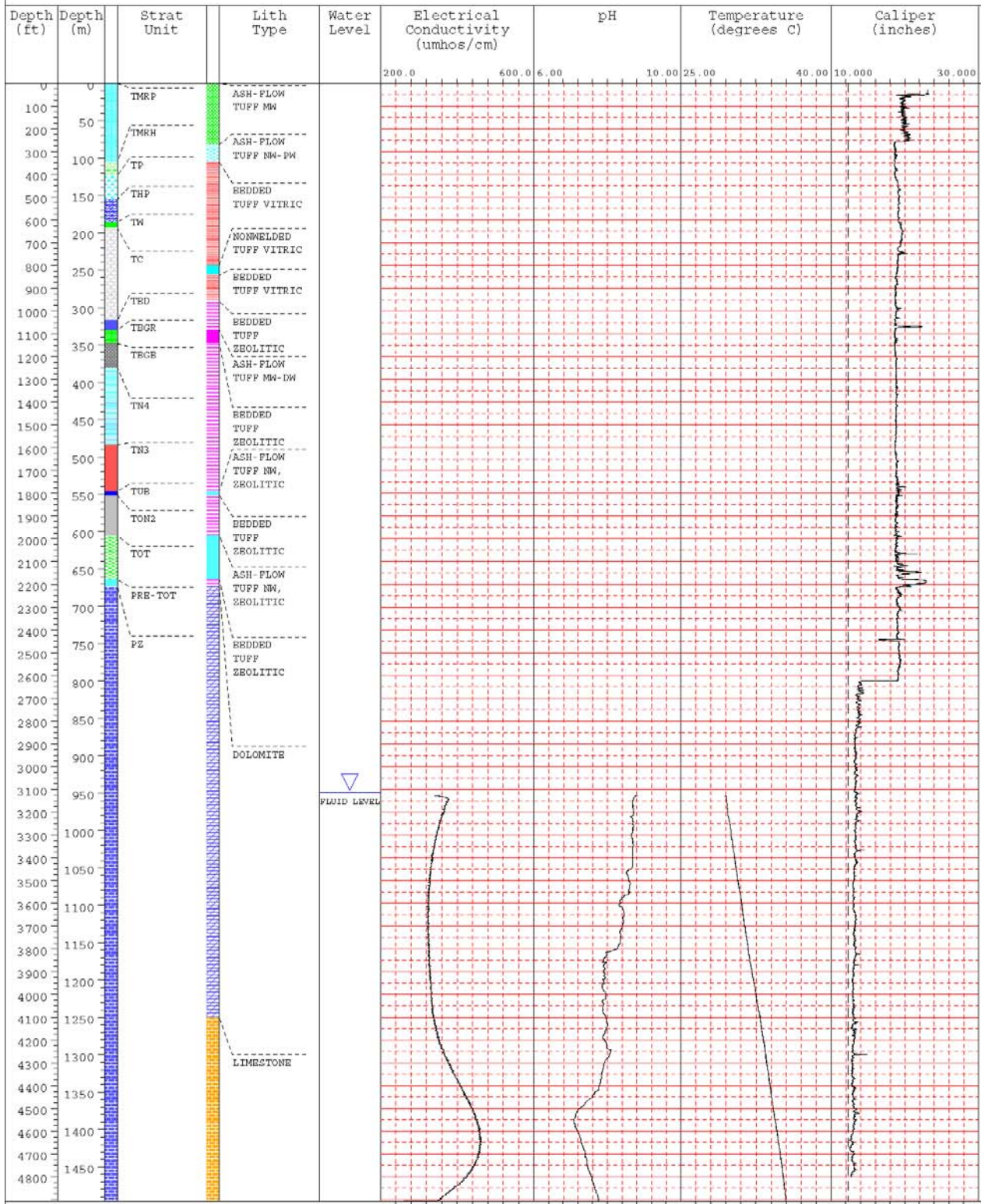
Well Name: ER-12-3	Rainier Mesa/Shoshone Mountain Drilling Program		Northing: 4,116,789.7 m
Date: 2/2/06	Start Date: 03/26/05	Stop Date: 04/28/05	Easting: 569,668.4 m
Environmental Contractor: UGTA/SNJV	Project No: UG05-630		Surface Elevation: 7390.8 ft
Drilling Contractor: UDI	Drilling Method: Air Foam Rotary	Geologist: J. Wurtz	Drilled Depth: 4,908 ft



Well Name: ER-12-3	Rainier Mesa/Shoshone Mountain Drilling Program		Northing: 4,116,789.7 m
Date: 2/2/06	Start Date: 03/26/05	Stop Date: 04/28/05	Easting: 569,668.4 m
Environmental Contractor: UGTA/SNJV	Project No: UG05-630		Surface Elevation: 7,390.8 ft
Drilling Contractor: UDI	Drilling Method: Air Foam Rotary	Geologist: J. Wurtz	Drilled Depth: 4,908 ft



Well Name: ER-12-3	Rainier Mesa/Shoshone Mountain Drilling Program		Northing: 4,116,789.7 m
Date: 2/2/06	Start Date: 03/26/05	Stop Date: 04/28/05	Easting: 569,668.4 m
Environmental Contractor: UGTA/SNJV	Project No: UG05-630		Surface Elevation: 7,390.8 ft
Drilling Contractor:	Drill Method: Air Foam Rotary	Geologist: J. Wurtz	Drilled Depth: 4,908 ft



Distribution List

Copies

W. R. Wilborn U.S. Department of Energy National Nuclear Security Administration Nevada Site Office Environmental Restoration Project P.O. Box 98518, M/S 505 Las Vegas, NV 89193-8518	5 (2 paper, 3 CDs)
U.S. Department of Energy National Nuclear Security Administration Nevada Site Office Technical Library P.O. Box 98518, M/S 505 Las Vegas, NV 89193-8518	1 paper (uncontrolled)
U.S. Department of Energy National Nuclear Security Administration Nevada Site Office Nuclear Testing Archive Public Reading Facility P.O. Box 98518, M/S 505 Las Vegas, NV 89193-8518	2 CDs (uncontrolled)
U.S. Department of Energy Office of Scientific and Technical Information P.O. Box 62 Oak Ridge, Tennessee 37831-0062	1 electronic (uncontrolled)
K. A. Hoar, Director U.S. Department of Energy National Nuclear Security Administration Nevada Site Office Environment, Safety, and Health Division P.O. Box 98518, M/S 505 Las Vegas, NV 89193-8518	1 paper
P. K. Ortego Bechtel Nevada P.O. Box 98521, MS NLV082 Las Vegas, NV 89193-8521	1 paper

Distribution List (continued)

	<u>Copies</u>
John McCord UGTA Project Manager Stoller-Navarro Joint Venture 7710 West Cheyenne Ave., Building 3 Las Vegas, NV 89129	1 paper
Stoller-Navarro Library Stoller-Navarro Joint Venture 7710 West Cheyenne Ave., Building 3 Las Vegas, NV 89129	1 paper
N. M. Becker Los Alamos National Laboratory P.O. Box 1663, EES-6, M/S F-665 Los Alamos, NM 87545-1663	1 paper
W. L. Hawkins Los Alamos National Laboratory P. O. Box 1663, EES-11, M/ F-665 Los Alamos, NM 87545-1663	1 paper
G. A. Pawloski Lawrence Livermore National Laboratory P. O. Box 808 Livermore, CA 94551-0808	1 paper
T. P. Rose Lawrence Livermore National Laboratory P. O. Box 808 Livermore, CA 94551-0808	1 paper
B. K. Thompson Water Resources Division, Nevada District U.S. Geological Survey 160 N. Stephanie Street Henderson, NV 89074	1 paper
C. E. Russell Desert Research Institute 755 East Flamingo Road P.O. Box 19040 Las Vegas, NV 89119-7363	1 paper