DOE/WIPP-05-3323

Basic Data Report
For Drillhole SNL-6 & -6A (C-3151)
(Waste Isolation Pilot Plant)

January 2010

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Basic Data Report
For Drillhole SNL-6 & -6A (C-3151)

(Waste Isolation Pilot Plant)

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January 2010

West Texas Water Well Service Rig #15 at SNL-6, taken toward southwest, on September 10, 2005. Photo by Dennis W. Powers.

EXECUTIVE SUMMARY

SNL-6 (permitted by the New Mexico State Engineer as C-3151) was drilled and completed in August-September 2005 to provide geological data and hydrological testing of the Culebra Dolomite Member of the Permian Rustler Formation in an area near the northeast corner of the hydrologic modeling domain for the Waste Isolation Pilot Plant (WIPP) site. This location was on the halite side of all mudstone-halite margins for the Rustler Formation. SNL-6 is located in the southeast quarter of section 7, T21S, R32E, in western Lea County, New Mexico. An initial well (SNL-6A) was drilled, cored, and then plugged and abandoned on this drillpad because it could not be completed. Geological information for SNL-6 is based on the cuttings, cores, and logs from SNL-6A, and that information is included in the report as appropriate.

SNL-6 was drilled to a total depth of 1,360 ft below ground level (bgl), based on driller's measurements. Below the caliche pad, SNL-6A encountered the Mescalero caliche, Gatuña Formation, Dockum Group, Dewey Lake Formation, and Rustler Formation. Two intervals of the Rustler were cored: 1) from the lower part of the upper Forty-niner Member anhydrite (A-5) to near the base of the Magenta Dolomite Member, and 2) from lower H-3 of the Tamarisk Member through the Culebra Dolomite and into the upper Los Medaños Member (H-2). Geophysical logs were acquired from the open hole at SNL-6A to a depth of ~1,360 ft. Water flowed into the open drillhole (SNL-6A) from the lower Dockum; no other water flows were identified because of Dockum inflow and because drilling continued with mist and soap, and later, brine mud.

The upper part of the Los Medaños has normal lithology and stratigraphic sequence, similar to areas east of WIPP. The upper part of the upper mudstone-halite unit (M-2/H-2) of the Los Medaños includes some bedded halite. Displacive and corroded halite occur near the top of H-2 beds. The contact with the overlying Culebra was recovered. The uppermost core from M-2 is well-laminated gray silty claystone, indicates no significant deformation, and grades sharply into the overlying dolomite.

Core recovery from the Culebra was complete, revealing a unit with little observable porosity. There are some narrow fractures within the core filled with halite. Vugs and sulfate nodules are tiny and rare. Bedding is well developed throughout the core, and it is dominated by thin sets with both wavy and rippled bedding. The more organic-rich zone common in the upper 1 ft of the Culebra is limited at SNL-6A. The Culebra is 22.5 ft thick in core. This is slightly thinner than is found nearer the WIPP site. Given the lack of apparent porosity and open fracturing, the Culebra is expected to show very low transmissivity.

The Tamarisk has a normal stratigraphic sequence for the area east of WIPP, near the center of the depositional basin. The basal sulfate (A-2) is mainly gray anhydrite that displays horizontal beds and laminae. A laminated thin siltstone and claystone ~10 ft above the Culebra persists across the WIPP area and is present at SNL-6A. The upper surface of A-2 is undulatory and appears eroded. At SNL-6A, halite (H-3) is present and thick, revealing stratigraphic details also distinguished during regional study of the unit. There is no distinctive mudstone bed, but argillaceous halite in the lower half of the Tamarisk is considered mainly equivalent in the regional study to mudstone facies to the west. A polyhalite bed and two thin anhydrites that are present regionally were encountered at SNL-6A. The upper Tamarisk sulfate (A-3) is 47 ft thick, consistent with other encounters in the area where H-3 is present and sulfate beds found in H-3 to the east are not part of the upper sulfate.

The Magenta Dolomite is 23 ft thick, slightly thinner than normal for the member. The core displays normal thin bedding and laminae

ranging from wavy to cross- and ripple-bedded to horizontal. The basal zone, which normally shows higher amplitude wavy bedding consistent with evidence of stromatolite forms, was not cored. Nodules are very limited. Few fractures are present, and halite fills wider apertures. There is neither core nor log evidence of a higher porosity zone that occurs in the upper middle section of many Magenta cores across the WIPP site.

The Forty-niner is represented by a sequence of sulfate–halite and mudstone–sulfate. The basal anhydrite (A-4) is 14 ft thick. The core shows laminae with carbonate and thicker bedding. Bedded halite (H-5) is overlain by reddish brown mudstone. The upper anhydrite (A-5) of the Forty-niner is 29 ft thick, and the cored lower part displays well-developed bedding and no brecciation. The contact with the overlying Dewey Lake appears sharp on the logs.

The Dewey Lake is thicker at SNL-6A (499 ft) than in drillholes farther west where the upper part of the formation has been eroded. The general depositional sequences of the Dewey Lake are broadly interpretable from density logs. [The natural gamma log, the easiest log to use in distinguishing these sequences, could not be obtained because the drillhole had squeezed partially shut at 350 ft.] Cuttings showed gypsum through most of the formation. This is among the higher stratigraphic positions where this cement has been encountered in WIPP drillholes.

The Dockum at SNL-6A is 489 ft thick and is represented by interbedded siltstones and sandstones that are multi-hued, though commonly reddish brown with a purplish cast. The lower ~290 ft is probably correlative with the Santa Rosa Formation, while the upper Dockum Group is probably equivalent to the Tecovas Formation. These units have not been formally assigned here because of uncertainty in correlation.

The Gatuña at SNL-6A is 27 ft thick and is mainly calcareous sandstone, with carbonate infiltrated at the top. This location is near the head of Bilbrey Basin, which leads southeast toward San Simon Swale. The Gatuña at SNL-6A likely developed in this drainage system.

The Mescalero caliche is calcareous sand to sandy limestone at SNL-6A. Strong laminae indicate at least Stage IV development.

Water was encountered in the lower Dockum while SNL-6A was being drilled. Measured water level recovery from overnight observations suggest a water level elevation of about 3,268 ft above mean sea level (amsl) or 996.1 m amsl.

SNL-6 was drilled to 594 ft with a diameter of 12.25 inches, and a steel casing (8.625 inches diameter) was cemented back to surface to provide control. The well was then drilled to 1,360 ft at total depth with a diameter of 7.875 inches below the steel casing. Fiberglass reinforced plastic (FRP) casing (2.47 inches inside diameter) was placed in the hole, with a screen interval across the Culebra Dolomite from 1,346.0–1,319.9 ft below the top of the connector on the conductor casing. A blank with cap was added to the bottom of the casing to 1,352 ft. Approximately 2.5 ft of FRP casing was left above the connector. The annulus was filled with 4/10 gravel to 1,305 ft, above the Culebra. HolePlug® was placed from 1,305–1,300 ft to isolate the Culebra from higher units. The annulus above the bentonite was cemented to the surface.

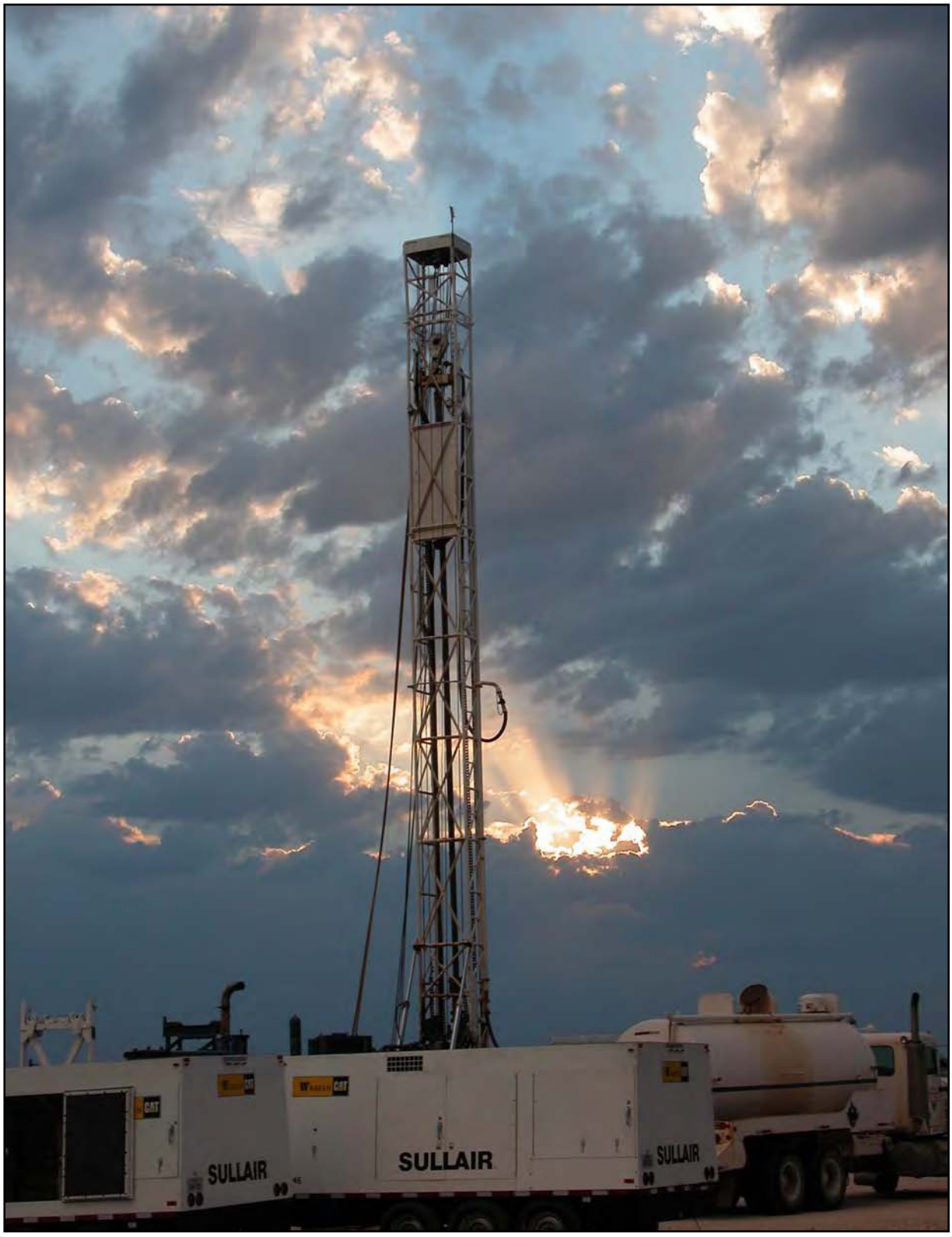
SNL-6 was completed September 10, 2005. The first water level recorded by Washington Regulatory and Environmental Services (WRES) was measured March 13, 2007; the initial depth to water was 954.77 ft below the top of casing.

Table of Contents

List of Figures and Tables

In keeping with practice at the WIPP site, the basic data for SNL-6 & -6A are reported in the inch-pound, or English, system; metric equivalents are given in one figure. The following conversion factors for metric equivalents may be useful:

MULTIPLY ENGLISH UNIT	BY	TO OBTAIN METRIC UNIT
foot (ft)	0.3048	meter (m)
inch (in)	25.4	millimeter (mm)
inch (in)	2.54	centimeter (cm)
pounds (lb)	0.4536	kilogram (kg)



West Texas Water Well Service Rig #15 at SNL-6A, taken toward east, early morning July 6, 2005. SNL-6A was plugged and abandoned. Photo by Dennis W. Powers.

1.0 INTRODUCTION

SNL-6 and SNL-6A were drilled in the southeast quarter of section 7, T21S, R32E, in western Lea County, NM (Figs. 1-1, 1-2). This location places the drillholes north-northeast of the WIPP site. An original drillhole (now designated SNL-6A) on the wellpad could not be completed and was plugged and abandoned (Fig. 1-3A). A second well (known as SNL-6) was drilled and completed on the same wellpad, and it is monitored for water levels. The focus of this report is the completed well (SNL-6), with reference as appropriate to geologic and other data from SNL-6A. Appendix material will be referred to in the text for details of drilling, logging, and plugging and abandoning of SNL-6A.

SNL-6 is located 1,847 ft from the south line (fsl) and 1,413 ft from the east line (fel) of the section (Fig. 1-2). SNL-6 was begun on August 23, 2005, and was completed September 10, 2005 (Table 1-1). SNL-6 is used to monitor groundwater levels of the Culebra Dolomite Member of the Permian Rustler Formation for WIPP in an area of low transmissivity and near the northeastern corner of the hydrological modeling domain.

SNL-6 was permitted by the NM State Engineer as C-3151. Official correspondence regarding permitting and regulatory information must reference this permit number.

Most drillholes at WIPP have been described after completion to provide an account of the geologic, hydrologic, or other basic data acquired during drilling and immediate completion of the drillhole. In addition, the basic data report provides an account of the drilling procedures and activities that may be helpful to later interpretations of data or for further work in the drillhole, including test activities and eventual plugging and abandoning activities. The basic data report also provides a convenient means of reporting information about administrative activities necessary to drill the hole.

1.1 Purpose of WIPP

WIPP is a U.S. Department of Energy (DOE) facility disposing of transuranic and mixed waste, byproducts of U.S. defense programs, as certified by the U.S. Environmental Protection Agency (EPA) and under a permit issued by the NM Environment Department. WIPP is located ~25 miles east of Carlsbad, New Mexico, in eastern Eddy County (Fig. 1-1). Disposal panels are being excavated in the Permian Salado Formation at a depth of ~2,150 ft bgl.

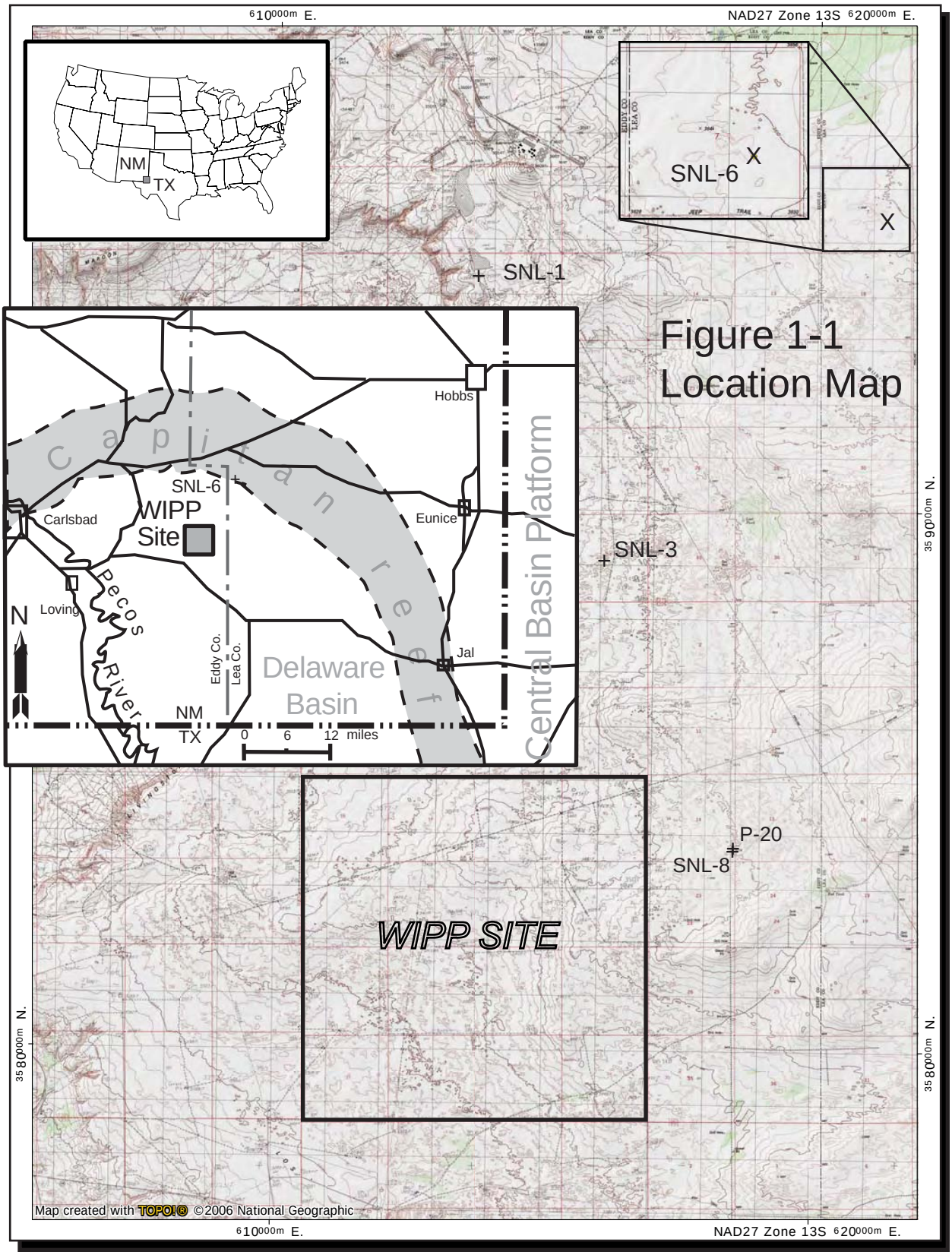
1.2 Purpose of SNL-6

SNL-6 was designed and located to provide information for the integrated hydrology program for the WIPP (Sandia National Laboratories [SNL], 2003) (see Appendix A). Objectives of the integrated hydrology program will help "… resolve questions related to observed water-level changes around WIPP site, provide data needed for comprehensive modeling of WIPP groundwater hydrology, [and] construct a groundwater monitoring network that can be maintained throughout the operational period of WIPP …" (p. 1).

SNL-6 was located north-northeast of WIPP where Culebra transmissivity is believed to be low, near the margin of halite in beds below and above the Culebra (SNL, 2003). Geologic data obtained from the drillhole would help confirm the effects of Rustler halite on Culebra hydraulic properties. SNL-6 was included in the program plan (SNL, 2003). From the program plan (SNL, 2003), SNL-6 is to:

1. Provide needed boundary conditions (both head and transmissivity) for the northeastern area of the Culebra flow model; and
2. Confirm the hypothesis in our conceptual hydrogeologic model that Culebra transmissivity is low in this region between the m2/h2 and m3/h3 halite margins.

Culebra water levels in many of the wells monitored for WIPP have been rising in recent


610000m E.
NAD27 Zone 13S
620000m E.
NM
TX
SNL-6
X
X
SNL-1
Figure 1-1
Location Map
Hobbs
Capitan Reef
SNL-6
WIPP
Site
Carlsbad
Eunice
Central Basin Platform
SNL-3
N
Loving
Pecos
River
Eddy Co.
Lea Co.
Delaware
Basin
Jal
NM
TX
0
6
12 miles
P-20
SNL-8
WIPP SITE
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3580000m N.
Map created with TOPO!® ©2006 National Geographic
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NAD27 Zone 13S
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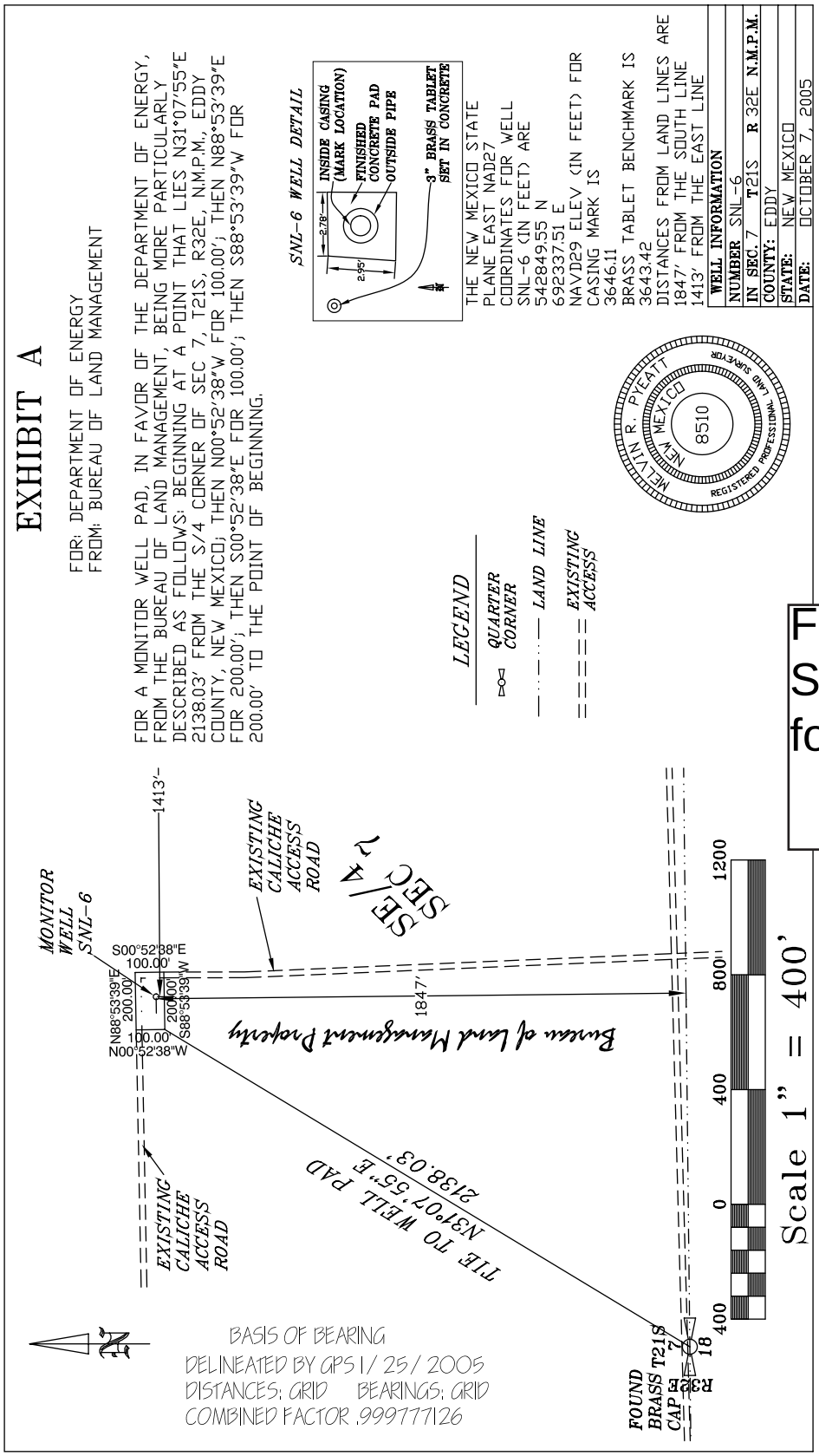


Figure 1-2
Survey Plat
for SNL-6

years, contrasting with the conditions used to calibrate models of the Culebra across the site area (SNL, 2003) for the Compliance Certification Application (CCA; U.S. DOE, 1996). Hydraulic properties of the Culebra vary spatially, and three factors (overburden, upper Salado dissolution, and Rustler halite distribution) appear to explain most of the variability in transmissivity (Holt and Yarbrough, 2002; Holt and Powers, 2002; Powers and others, 2003). The Compliance Recertification Application (CRA; U.S. DOE, 2004) submitted to the EPA models release scenarios through the Culebra using transmissivity fields based on these factors.

1.3 SNL-6 Drilling and Completion

The basic information about drilling and completion of SNL-6 is presented here in tabular form (Table 1-1) and graphics (Figs. 1-3, 1-4, and 1-5) for ease of reference. Appendix B includes details based on daily drilling logs for SNL-6A as well as SNL-6.

SNL-6 was rotary drilled to a total depth of 1,360 ft bgl (Fig. 1-3B) as measured during drilling. SNL-6 was drilled with air and air mist to 594 ft at a diameter of 12.25 inches. A steel casing 8.625 inches in diameter was cemented back to the surface to control moist zones in the lower Dockum Group; these intervals created problems during drilling of SNL-6A. SNL-6 was then drilled to total depth at a diameter of 7.875 inches using air and brine mist. No cuttings or core were recovered from SNL-6. Stratigraphic units were assumed to be at very similar depths in SNL-6 as were determined by drilling, coring, and logging in SNL-6A.

SNL-6A cuttings and core records are included in Appendix C. Core recovery from SNL-6A was very good (~94%; Table 1-1) and was nearly complete through the Culebra. Complete core recovery is rare through the Culebra (e.g., Powers, 2002b; Mercer and others, 1998). Geophysical logging of SNL-6A was successful with the density tool to below the Culebra. Natural gamma logging was abandoned when the tool could not pass below ~350 ft (Appendix D).

In keeping with recent practice at WIPP, SNL-6 was cased with fiberglass reinforced plastic (FRP) casing rather than steel to provide longer utility of the well for monitoring and testing. Steel-cased wells at WIPP are expected to be plugged and abandoned and, where necessary, replaced with wells completed with FRP casing (SNL, 2003). The FRP casing was smaller (2.47 inches inside diameter) than for most WIPP wells, anticipating very slow recovery from the Culebra.

SNL-6 was completed with a single screened interval for monitoring and testing of only the Culebra Dolomite (Fig. 1-4). With a single completion interval, some of the difficulties associated with multiple completions can be avoided: expense of buying, placing, and maintaining packers; loss of water-level data when packers fail; mixing of waters of differing qualities when packers fail; and the increased complexity of testing in a well completed to multiple intervals.

Geophysical logs from SNL-6A, especially the density and caliper logs, were used to make the final decisions regarding completion of SNL-6 (Fig. 1-4) (Appendices D and G). The drillhole penetrated the uppermost part of the lower Rustler (Fig. 1-4). The bottom of the Culebra screen interval, at 1,346 ft, is slightly above the claystone below the Culebra. The top of the screen, at 1,319.9 ft, is above the top of the Culebra. The top of the gravel pack (4/10 silica gravel) at 1,305 ft is below the level of the mudstone in the Tamarisk to prevent connection to the Culebra. Mudstones above and below Culebra show halite, as does the Culebra. Bentonite (HolePlug®) was placed to 1,300 ft, and the annulus above the bentonite was cemented to the surface. The caliper log (Fig. 1-3A) of SNL-6A showed some drillhole enlargement in the Forty-niner mudstone/halite unit; this zone is not likely to have been greatly enlarged in SNL-6 due to a shorter drilling period.

The surface configuration (Fig. 1-5) provides stability, security, and ready access to the casing for measurements, sampling, or other testing. The surface benchmark is an accessible reference point for future measurements if the well configuration is changed.

A steel surface conductor casing (8.25-inch inner diameter) was cemented in place to a depth of 594 ft below the surface, with the top of the conductor casing cut off ~6 inches above the drilling pad level (Fig. 1-5) serving as a common reference point for drilling and placing the screened interval, sand pack, bentonite seal, and cement. The top of the steel connector was estimated to have an elevation of 3,643 ft amsl, based on a predrilling survey of the well pad. The benchmark placed at the drilling pad surface next to the completed well has an elevation of 3,643.42 ft amsl (after resurvey 2007) and is very close to the elevation of the connector on the casing. *Other than water-level monitoring, depths are stated as bgl, and the top of the steel connector on the surface conductor casing is taken as a proxy reference point for ground level with an elevation of ~3,643 ft amsl (Table 1-1; Figs. 1-3, 1-4, and 1-5).* The FRP casing projects ~2.5 ft above the steel connector on top of the conductor casing. This FRP casing point is surveyed (Fig. 1-5), and it provides the reference point and reference elevation (3,646.11 ft amsl; after resurvey, 2007) for monitoring water levels.

1.4 Other Background

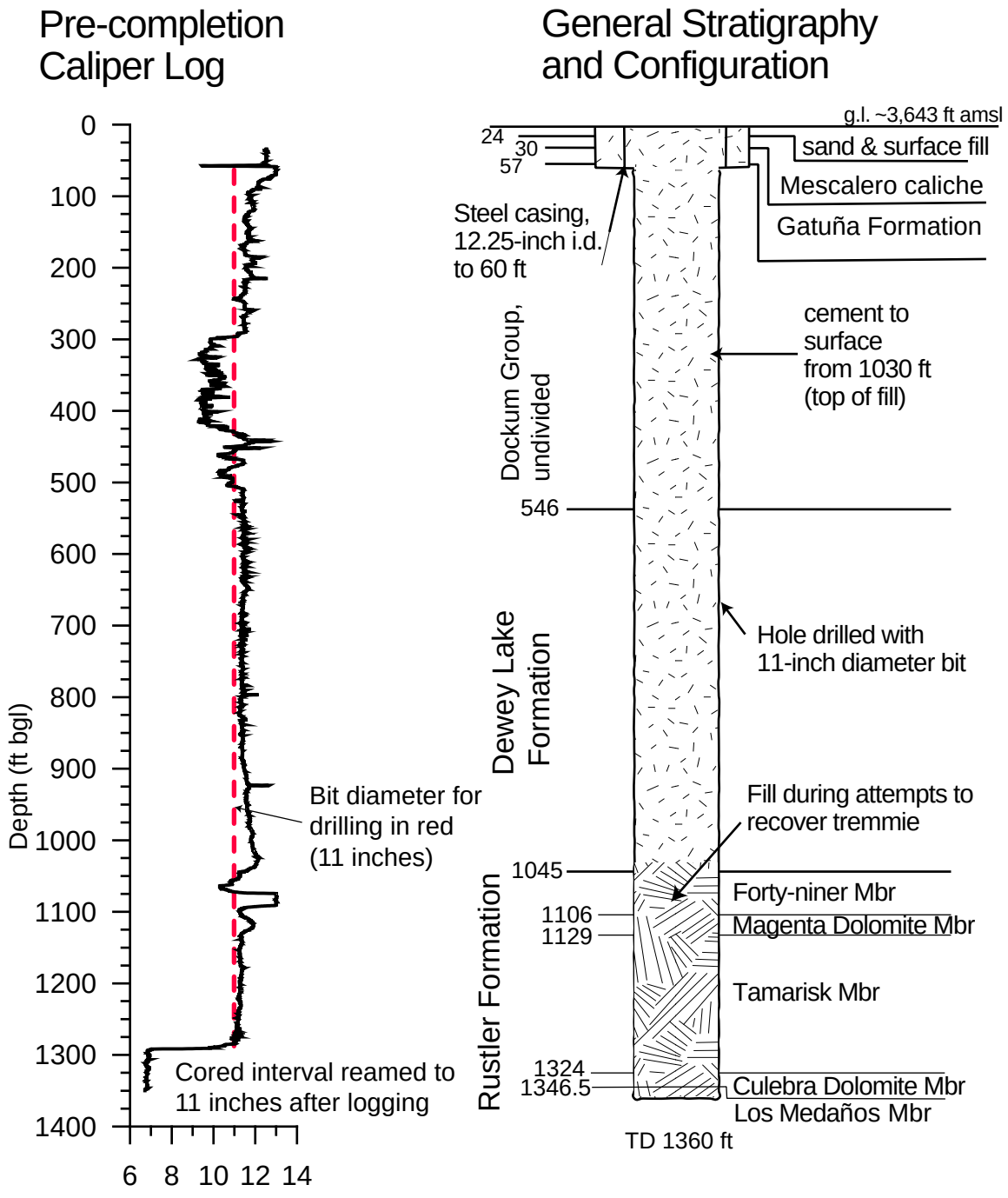
SNL-6 was drilled and completed by the West Texas Water Well Service, 3410 Mankins, Odessa, Texas, under contract from Washington TRU Solutions LLC (WTS). Coring was done by Billy Pon, Diamond Oil Well Drilling Co., Inc., P.O. Box 7843, Midland, Texas. Geophysical logging was conducted by Al Henderson, Jet West Geophysical Services, LLC, 2550 La Plata Highway, Farmington, NM, 87499-3522, under contract to West Texas Water Well Service. Geological support was provided by Dennis Powers under contract to WTS. Mike Stapleton of the NM Office of the State Engineer witnessed hole completion activities (Appendix D). Well drilling wastes (cuttings) were removed from SNL-6 and SNL-6A and disposed of at the Lea Land, Inc., landfill north of WIPP. Archeological clearances obtained from the U.S. Bureau of Land Management were based on field work and reports by Mesa Field Services, Carlsbad, NM (Appendix E). Cores from SNL-6A were photographed with a digital camera, and a photo log is included in Appendix F. Electronic images can be requested from WTS.

Formal color designations (e.g., weak red: 5YR5/4) included in the text and Appendix C are based on the 1971 edition of the Munsell Soil Color Charts. The names may differ from the general color observed; the rocks are compared when dry unless otherwise specifically noted.

1.5 Acknowledgments

Drafts of this document were reviewed by Erik Powers, Wayne Stensrud, Rick Salness, Joel Siegel, Tricia Johnson, and Rick Beauheim, and their comments improved the final report. Mark Crawley (Washington Regulatory and Environmental Services - WRES) provided field support and information on well development. Doug Lynn (WRES) obtained permits and provided permitting and regulatory information included in appendix material. Erik Powers prepared draft illustrations for Appendix C. Ronny Keith and Luis Armendariz (West Texas Water Well Service) provided drilling data and daily drilling records. West Texas Water Well Service personnel were very helpful in providing access for sampling during drilling. Al Henderson (Jet West Geophysical Services) provided the printed and electronic files that were used to develop Figure 2-1. Vivian Allen (L&M) provided useful editorial guidance.

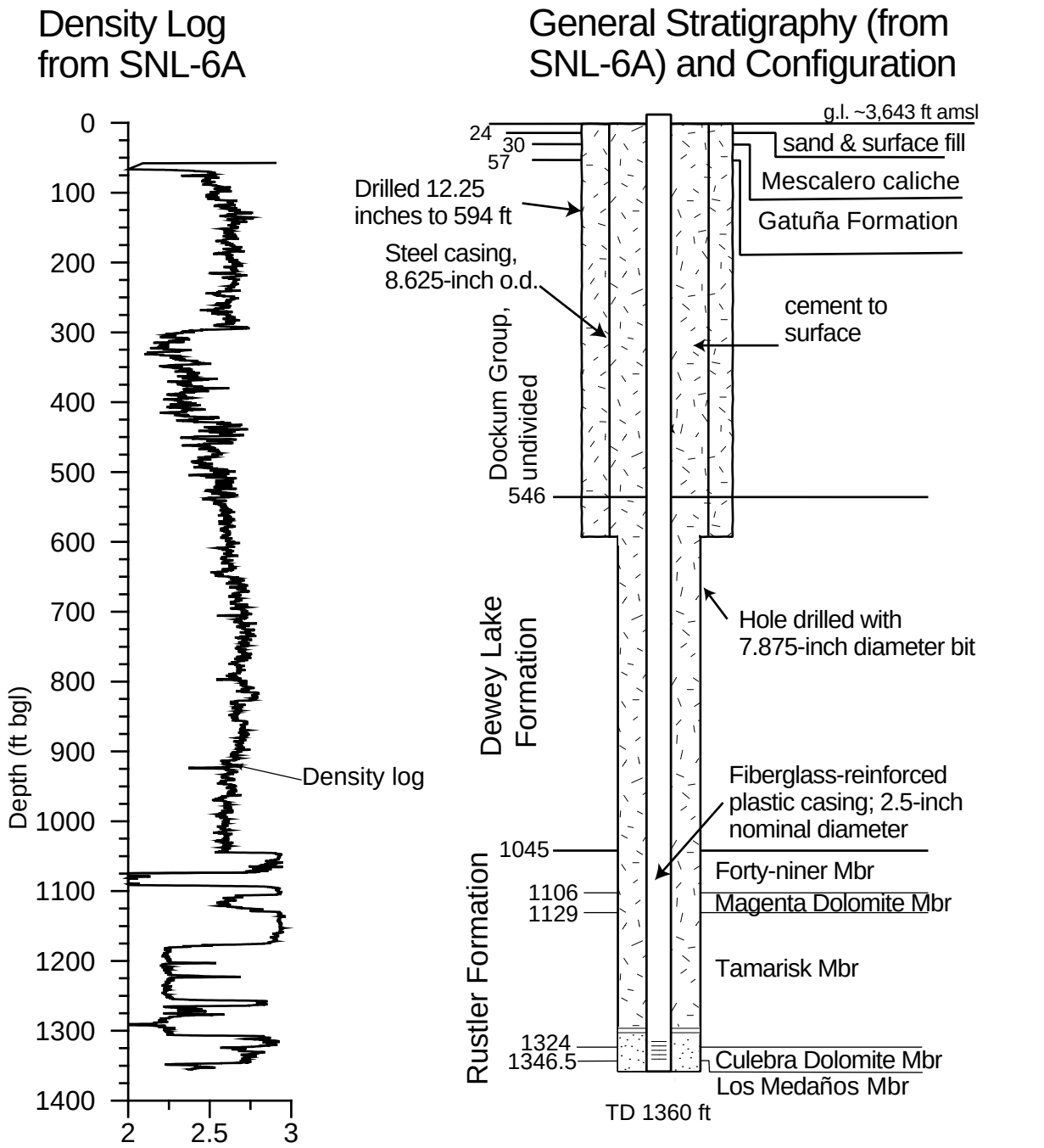
Figure 1-3A
SNL-6A Plugged & Abandoned



SNL-6A Diameter (inches)
(reamed to 1,292 ft before logging)
See Figures 1-4 and 1-5 for
additional details

Note: Depths for drilling, geophysical logs, and P&A are referenced to the top of the steel connector on the surface conductor casing near the surface of the drilling pad at SNL-6 and is taken as 3,643 ft amsl.

Figure 1-3B
SNL-6 Completion Diagram



SNL-6A Density Log (g/cm^3)
See Figures 1-4 and 1-5 for additional details

Note: Depths for drilling, geophysical logs, and casing referenced to the top of the steel connector on the surface conductor casing near the surface of the drilling pad at SNL-6 and is taken as 3,643 ft amsl.

Table 1-1. Summary of Drilling and Well Completion Records for Hydrologic Drillhole SNL-6 (C-3151)

LOCATION: Southeast ¼, Section 7, Township 21 South (T21S), Range 32 East (R32E)

SURFACE COORDINATES: The well is located 1,847 ft from the south line (fsl) and 1,413 ft from the east line (fel) of Section 7. The New Mexico State Plane (NAD 27) horizontal coordinates in feet are 542849.55 North, 692337.51 East (Fig. 1-2 shows the survey plat). Universal Transverse Mercator (UTM) horizontal coordinates (NAD27, Zone 13) in meters were calculated for SNL-6 using Corpscon for Windows (v. 6): 621244.15 East, 3595389.87 North. Figure 1-1 shows UTM coordinates on a 1,000-m grid.

ELEVATION: All depths from geological and geophysical data used for completion were measured from the surface conductor casing just above the level of the drillpad surface (Fig. 1-5). Depths are reported as bgl, which is taken as 3,643 ft amsl, the rounded value for the brass tablet benchmark (3,643.42 ft amsl) adjacent to the cement well pad. The primary datum for the completed well is 3,646.11 ft amsl (NGVD 29) for a mark on the top of the fiberglass reinforced plastic casing inside the protective well pipe. Figures 1-3B, 1-4, and 1-5 show the as-built configuration of SNL-6.

DRILLING RECORD (SNL-6 only):

Dates: Began drilling August 23, 2005; drillhole reached total depth (1,360 ft) on September 7, 2005. SNL-6 was cased and cemented September 10, 2005. Water was blown from the casing at SNL-6 to a depth of 1306 ft on September 13, 2005, and the water level had not risen above that level on September 14, 2005. [See Appendix B for daily notes on drilling and plugging and abandoning SNL-6A.]

Circulation Fluid: SNL-6 was drilled to 195 ft bgl with circulating air. From 195 ft to 594 ft, air and mist (with Quik-Foam®) were used to return cuttings. Surface casing was installed to 594 ft, and drilling resumed with air. After damp cuttings were encountered from 1,070 ft, drilling continued to TD with air and brine mist (with Quik-Foam®). Cuttings during all drilling were discharged into a lined portable steel container.

Cored Intervals (SNL-6A): 4.0-inch core was taken through these intervals (depths from drilling data):

1,070.0–1,128.0 ft bgl: upper Forty-niner to lower Magenta Dolomite Members
1,292.0–1,357.0 ft bgl: lower Tamarisk, Culebra Dolomite, and upper Los Medaños Members

Rig and Drilling Contractor: Gardner-Denver 1500; West Texas Water Well Service, Odessa, Texas

Table 1-1. Summary of Drilling and Well Completion Records for Hydrologic Drillhole SNL-6 (C-3151), continued

Drillhole Record:

Size (inches)	From (ft bgl)	To (ft bgl)
12.25	0	594
7.875	594	1360

Casing Record:

Outside diameter (inches)	Inside diameter (inches)	Weight/ft (pounds)	From (ft bgl)*	To (ft bgl)
8.625	8.25	24	-3	594
2.84**	2.47	1.40** FRP*** blank	-2.5	1346.0
2.84**	2.47	1.40** FRP screen (0.070")	1319.9	1346.0
2.84**	2.47	1.40** FRP blank	1346.0	1352.0

*Top of the casing connector is approximately at pad level. The reference for depth denoted bgl is the pad level. The FRP extends ~2.5 ft (-2.5) above the steel casing connector. Above the connector, 3 ft of steel casing were added for security.

**The FRP casing installed in SNL-6 is mixed: 2.5-inch Yellow Box 2000, 2.5-inch Yellow Box 2500, and 2.875-inch Red Box 2500. All have the same nominal inside diameter of 2.47 inches. Outside nominal diameters are 2.84, 2.94, and 2.99 inches, respectively. Nominal weights (lb/ft) are 1.4, 1.8, and 2.0, respectively.
Source: http://futurepipe.com

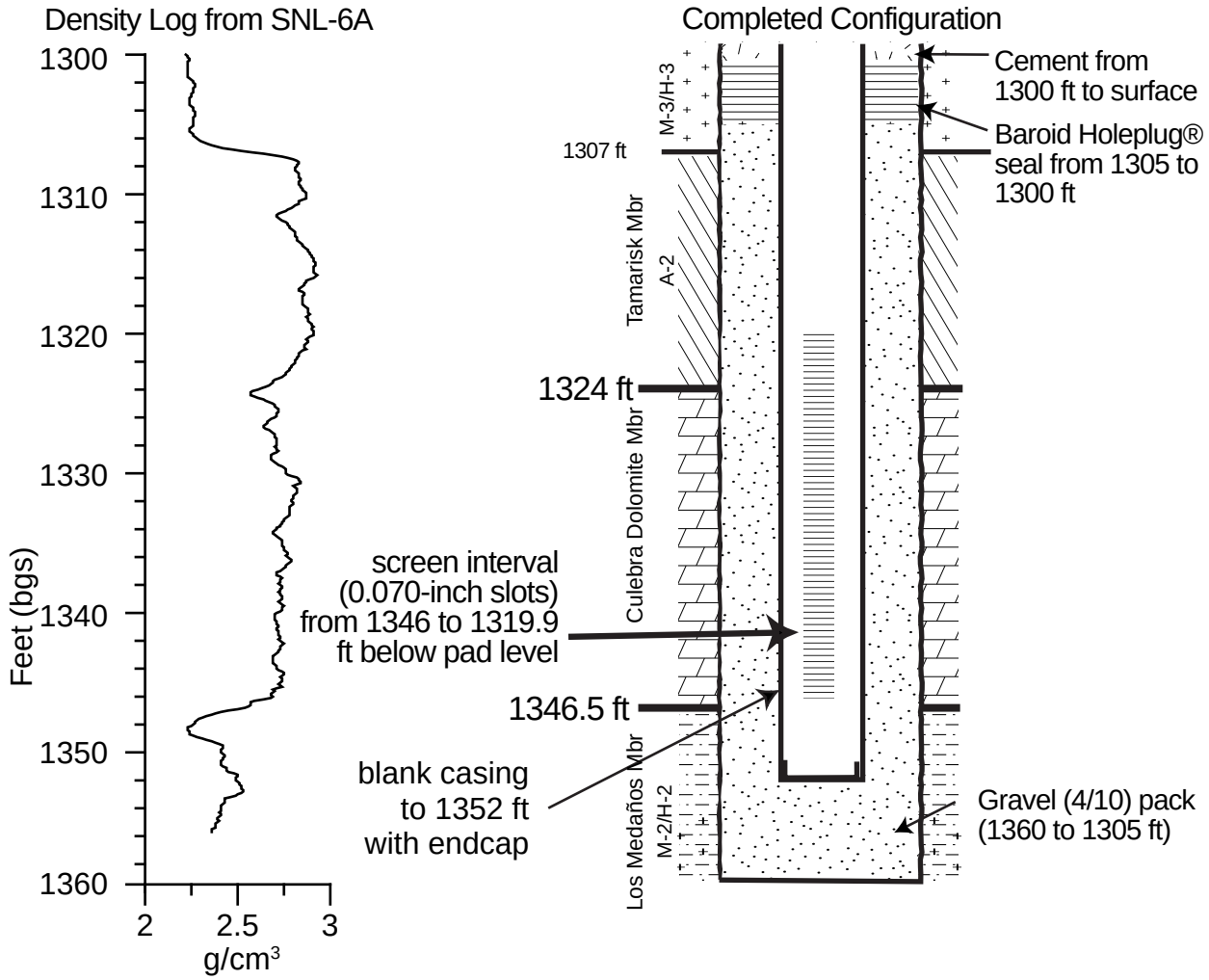
***FRP: fiberglass reinforced plastic

Coring Record (SNL-6A):

Core Run No.	Depth Interval (ft) From	To	Interval (ft) Cored	Recovered	Recovered %
1	1070	1098	28	22.3	79.64%
2	1098	1128	30	30	100.00%
3	1292	1322	30	30	100.00%
4	1322	1327	5	4.3	86.00%
5	1327	1357	30	29.5	98.33%
		Totals	123	116.1	94.39%

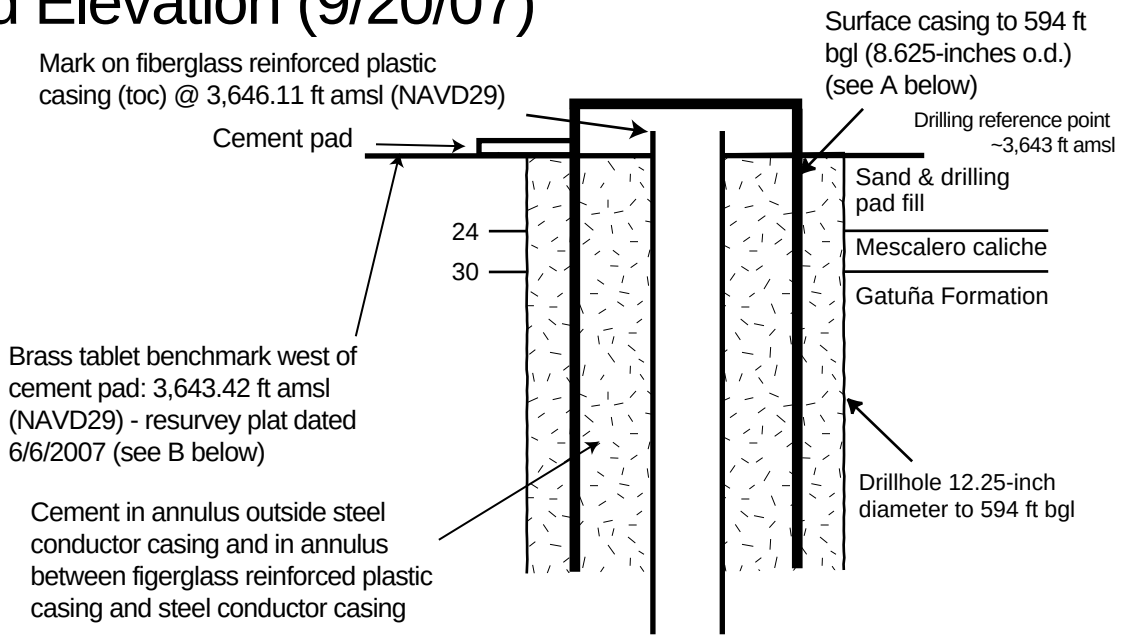
Note: The interval measured on recovered core may exceed the length measured during coring because core doesn't fit together precisely, some core from a previous run may be subsequently recovered, or depth measured during coring varies slightly.

Figure 1-4
SNL-6 Completion and Monitoring Configuration (9/10/05)



Note: Lithologic contacts below logged area are based on coring depths.

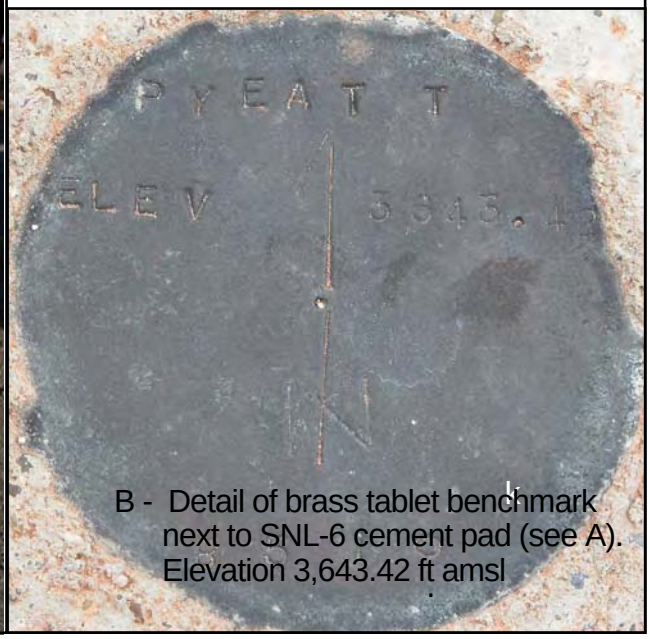
Figure 1-5
SNL-6 Surface Configuration and Elevation (9/20/07)



Note: Drawing is not to scale

A - taken June 9, 2008 (courtesy of WRES).
B - taken September 20, 2007

A - Foreground surface casing for SNL-6 with P&A SNL-6A in background. Casing cover is unlocked (lower left) for access.



B - Detail of brass tablet benchmark next to SNL-6 cement pad (see A). Elevation 3,643.42 ft amsl

West Texas Water Well Service Rig #15 at SNL-6 on September 10, 2005, near total depth. Photograph by Dennis W. Powers.

2.0 GEOLOGICAL DATA

2.1 General Geological Background

The geology and hydrology of formations at the WIPP site and surroundings have been intensively investigated since 1975, and the information and interpretations have been reported in numerous documents. The most thorough compilation is certainly the Compliance Certification Application (CCA) submitted in 1996 by the DOE to the EPA (U.S. DOE, 1996). Some salient features of the broader geological history, as well as more recent work on the geohydrology of the Rustler (e.g., Holt and Yarbrough, 2002; Holt and others, 2005; Powers, 2002a, 2003a; Powers and others, 2003), are relevant to understanding the geology and hydrology at SNL-6A and SNL-6.

The Delaware Basin (Fig. 1-1) was a large structural feature that controlled deposition through much of the Paleozoic. By late Permian, the basin connection to the open ocean was restricted, and evaporite minerals were precipitated in abundance to fill the basin. Near the end of the Permian, circulation with the ocean improved, and some of the Rustler, for example, was deposited in saline water rather than brine. As the Permian ended and Triassic began, significant redbeds were deposited in non-marine environments. Although surrounding areas accumulated variable thicknesses of later Mesozoic and Cenozoic age sediments, the WIPP area appears mainly to have been subject to erosion during an extended period. Some basin tilting from middle to late Cenozoic time exposed the evaporite beds to faster solution and erosion, and weathered material began to accumulate. The Pecos River drainage became integrated through the region during this period, and more recent deposits reflect such a sedimentary environment as well as sources of sediment from outside the local area. Although the region continues to be subject to some dissolution of evaporites and erosion, large areas have remained geologically stable for about the last half million years, resulting in the formation and preservation of pedogenic calcrete (caliche) deposits.

2.2 Geological Data From SNL-6A

SNL-6A encountered a normal stratigraphic sequence from ground level to total depth for this location east of the WIPP site area, (Fig. 2-1; Table 2-1). Units encountered ranged from unconsolidated surface sand to the upper part of the Los Medaños Member of the Permian Rustler Formation. Structural, sedimentological, and diagenetic features were examined during investigation using cuttings, cores, and geophysical logs. Details of the sedimentology of the Rustler will extend understanding of that unit. Water was produced from the lower Dockum Group during drilling in sufficient quantity to modify drilling to use mist and, during drilling of SNL-6A, circulating brine. It was indeterminable while drilling if other units encountered below Dockum produced water.

The geologic units encountered in SNL-6A are described from total depth to the surface, in the order in which they were deposited rather than in the order in which they were encountered in the drillhole. Cores and cuttings were described in the field using mainly drilling depths for depth control. Geologic logs detailing field observations of cuttings and cores from SNL-6A are included in Appendix C. The difference between geophysical logs and drilling depths is generally slight. Decisions about placing screen intervals and annulus fillings were based on depths indicated by geophysical logs (Appendix G).

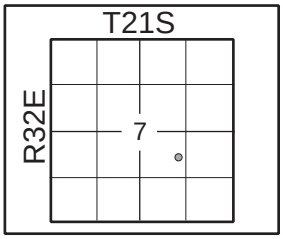
Note that the descriptions that follow use depths that correspond to core markings, with basic stratigraphic intervals provided by geophysical logs, as indicated.

2.2.1 Permian Rustler Formation

The Rustler was drilled and cored into the upper Los Medaños Member. The contact between the Rustler and the overlying Dewey Lake Formation is at 1,045 ft (Fig. 2-1; Table 2-1), and 315 ft of the Rustler were penetrated at SNL-6A (Table 2-1).

Figure 2-1
Well Record SNL-6A (C-3151)

Company: Washington TRU Solutions LLC
Well: SNL-6A (C-3151)
Section: 7 Twp: T21S Rge: R32E
Location (SNL-6): 1,847 ft from south line (fsl)
1,413 ft from east line (fel)



Reference point
Log measured from: top of connector on conductor casing (gl)
Drilling measured from: gl
Permanent Datum: benchmark

Elevation
KB:
DF:
GL: 3,643 ft amsl
(benchmark: 3,643.42)

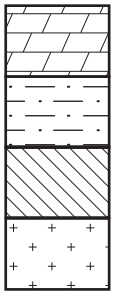
Drilling contractor: West Texas Well Water Service
Coring contractor: Diamond Oil Well Drilling Co.
Geophysical logs: Al Henderson
Jet West Geophysical Services, LLC (NM)
Geologist: Dennis W. Powers
Spud date: July 5, 2005
Plug & abandon date: August 2, 2005
Total depth (TD): 1,360 ft bgl (driller log)

Casing Record
Conductor: 60 ft
12.75-inch o.d. steel
Casing: N/A
Screened interval: N/A
Note this casing record is for SNL-6A, not SNL-6 (not logged)

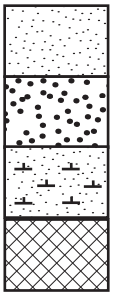
Geophysical Logs Date: July 28, 2005
Micro/Laterolog/SP: 0-1,352 ft
Gamma/Fluid: not obtained
Caliper: 0-1,350 ft
Density/Neutron: 0-1,356 ft

Type fluid in hole: brine with bentonite
Res mud: n/a
Res mud filtrate: n/a
Max. Rec. Temp.: not recorded

General Lithologic Symbols Used



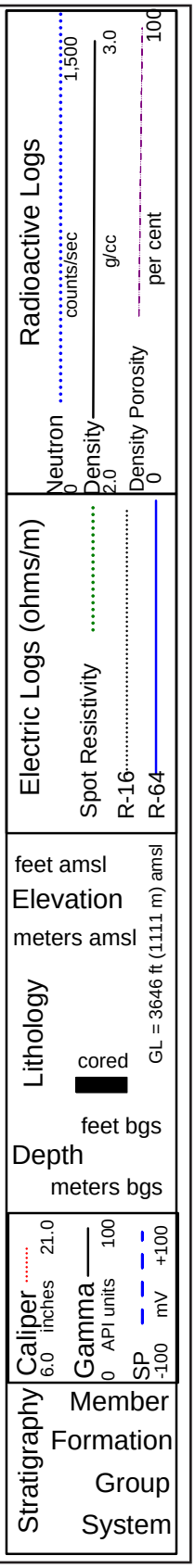
Dolomite
Mudstone/siltstone
Anhydrite
Halite

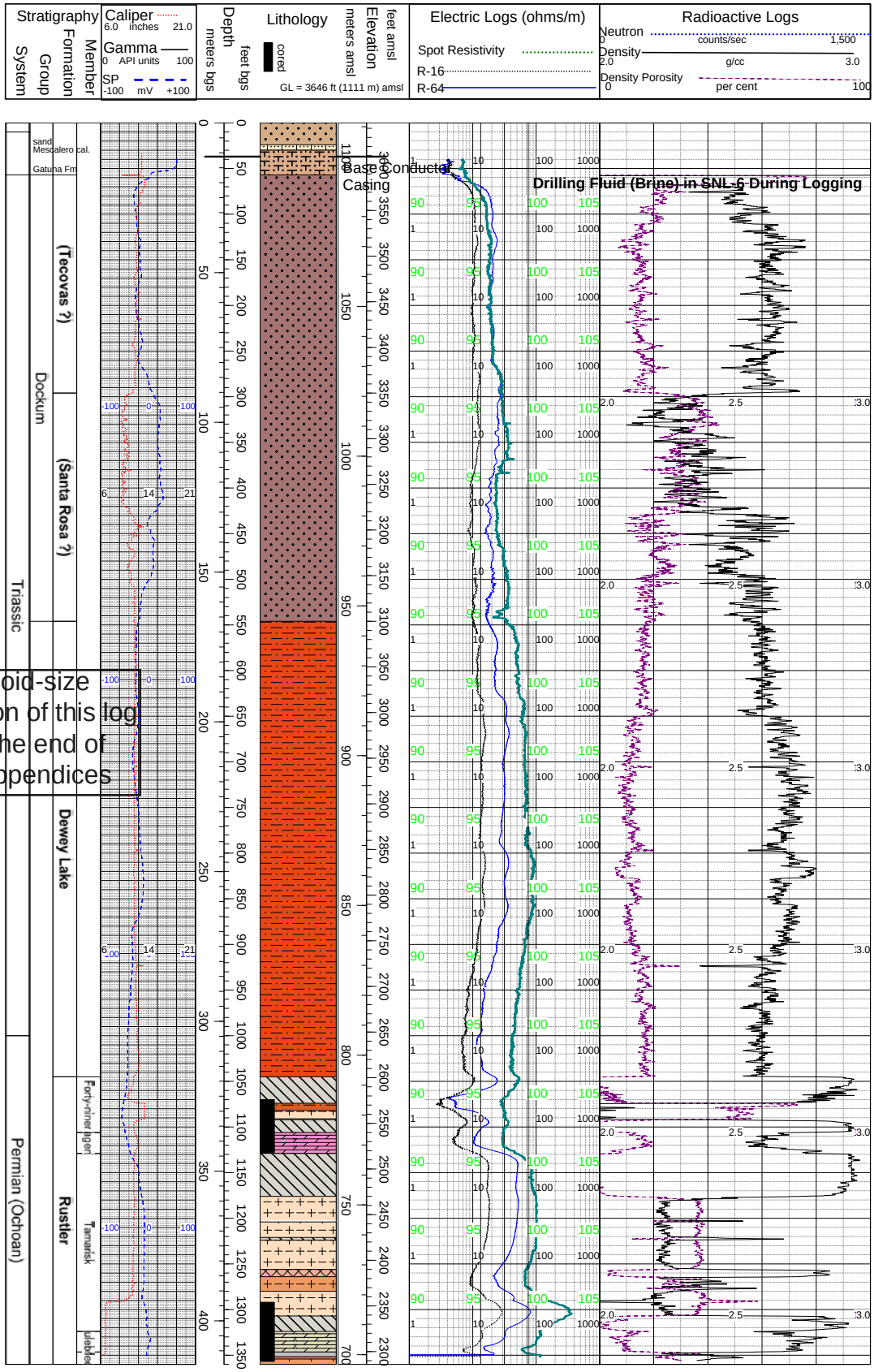


Fine sandstone & siltstone
Coarse sandstone
Sandstone w/caliche
Polyhalite

Figure 2-1 Log Title & Header page.ai

SNL-6A Well Log Headers





A tabloid-size version of this log is at the end of the appendices

Table 2-1
Geology at Drillhole SNL-6[1]

System/ Period/Epoch		Formation or unit	Member *Informal units*	Depth below surface (ft)[2] *log depths*	*core marks*
Cenozoic	Holocene	surface dune sand and pad fill		0 - 24 ft	
	Pleistocene	Mescalero caliche		24 ft - 30 ft	
	Miocene-Pleistocene	Gatuña		30 ft - 57 ft	
Mesozoic	**Triassic**	Dockum Group, undivided		57 ft - 546 ft	
		Dewey Lake[3]		546 ft -1045 ft	
Paleozoic	**Permian**	Rustler	Forty-niner *A-5* *M-4/H-4* *A-4*	1045 ft - 1106 ft *1045 ft - 1074 ft* *1074 ft - 1092 ft* *1092 ft - 1106 ft*	1070 ft - 1107.5 ft *1070 ft - 1076.0 ft* *1076.0 ft - 1094.6 ft* *1094.6 ft - 1107.5 ft*
			Magenta Dolomite	1106 ft - 1129 ft	1107.5 ft - 1128 ft
			Tamarisk *A-3* *M-3/H-3* *A-2*	1129 ft - 1324 ft *1129 ft - 1176 ft* *1176 ft - 1307 ft* *1307 ft - 1324 ft*	1292 ft - 1328.3 ft *not cored* *1292 ft - 1307.3 ft* *1307.3 ft - 1323.8 ft*
			Culebra Dolomite	1324 ft - 1346.5 ft	1323.8 ft - 1346.6 ft
			Los Medaños[4] *M-2/H-2*	1346.5 ft - 1360 ft *1346.5 ft - 1360 ft (TD)*	1346.6 ft - 1356.0 ft *1346.6 ft - 1356.0 ft*

[1]Data are from SNL-6A, near SNL-6.

[2]Depths are based on measurements by geophysical logging; drilling and coring provided supplemental data to total depth (TD) of 1,360 ft bgl. Geophysical logs and drilling/coring depths begin at the top of the connector on the surface steel conductor casing. This reference point is taken as 3,643 ft amsl; it is near the elevation of the surface benchmark adjacent to SNL-6. Water level depths will be measured and reported relative to the surveyed point on the top of the fiberglass reinforced plastic casing (Fig. 1-5). Geological logs based on field descriptions (Appendix C) and markings on cores (Appendix F) vary modestly from log depths.

[3]The Dewey Lake Formation has been considered part of the Permian System in the past. Recent work (Renne and others, 1996, 2001) indicates that lithologically equivalent rocks in Texas are mostly Lower Triassic, with some Upper Permian at the base.

[4]The Los Medaños Member was named by Powers and Holt (1999) to replace the informal unit "unnamed lower member" of the Rustler Formation.

2.2.1.1 Los Medaños Member

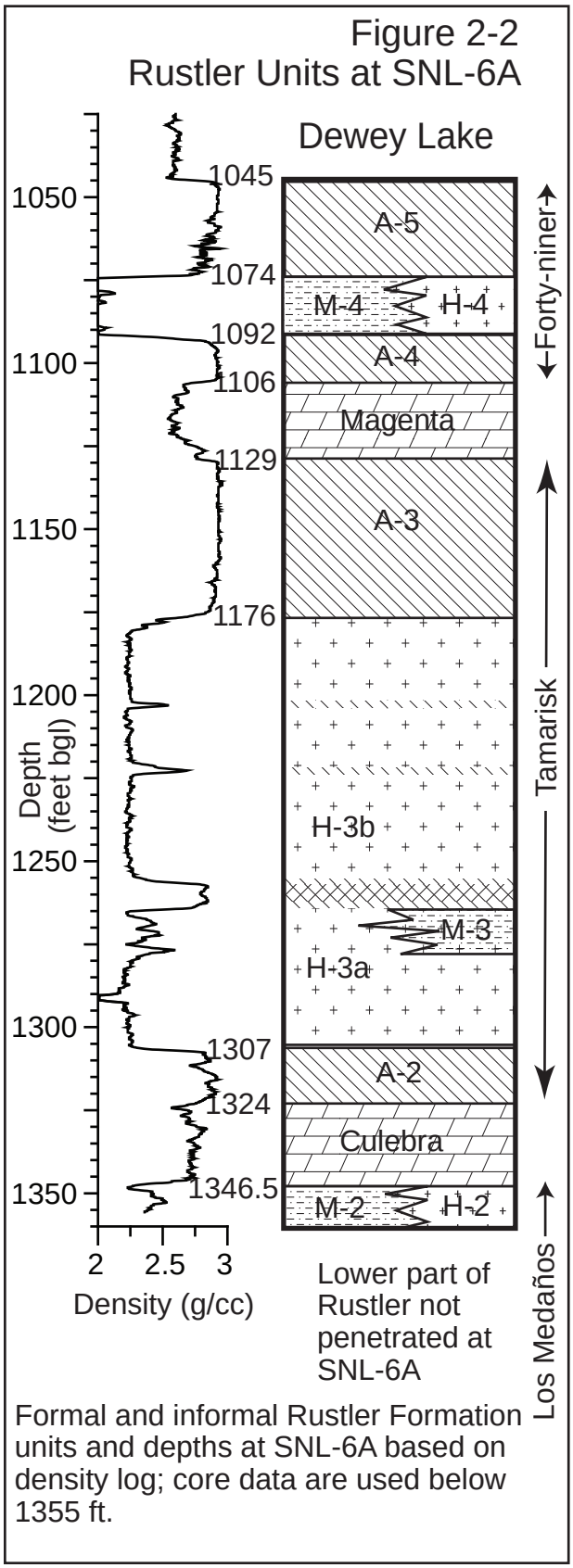
The Los Medaños was named by Powers and Holt (1999) based on the rocks described in shafts at the WIPP site. For the area around WIPP, studies of the Rustler have commonly referred to this interval from the base of the Culebra Dolomite Member to the top of the Salado Formation as the unnamed lower member of the Rustler. Holt and Powers (1988) and Powers and Holt (1999) also informally subdivided the Los Medaños into five units: a bioturbated clastic interval at the base, a sandy transition zone, a lower mudstone-halite 1 (M-1/H-1), anhydrite 1 (A-1), and an upper mudstone-halite 2 (M-2/H-2). Halite margins for the Los Medaños below A-1 have been treated as a single composite unit (Powers, 2002a), called M-1/H-1, because halite below A-1 is not restricted to the thinner zone designated M-1/H-1 in these earlier publications. Only M-2/H-2 was encountered in SNL-6A (Fig. 2-2; Table 2-1).

The informal unit *mudstone-halite 2* (M-2; Fig. 2-2) was encountered from 1,360–1,346.5 ft bgl, based on logging, coring, and drilling depths. The interval was cored to 1,357 ft, based on driller's depths, with core marked from 1,356–1,346.6 ft. The density log and core show a sharp contact at the top of M-2 (Fig. 2-1).

From 1,356–1,354.2 ft, the core is halite, light reddish, coarse to very coarse upward, with more clay and sulfate in the basal 1 ft (Fig. 2-3).

From 1,354.2–1,351.6 ft, the core is generally reddish brown, argillaceous siltstone with clasts of reddish brown siltstone and gypsum or anhydrite. Clasts are generally angular, up to 2 inches in diameter, and may increase in size upward. Fractures at ~45° from horizontal are filled with gypsum. The basal contact over halite is sharp and undulatory.

From 1,351.6–1,346.6 ft, the core is generally dark gray silty claystone with reddish brown hues near the base. The interval is gypsiferous at ~1,350.6 ft with gypsum fracture fill. A near-vertical planar fracture with no fill is present from



Formal and informal Rustler Formation units and depths at SNL-6A based on density log; core data are used below 1355 ft.

1,350-1,347.5 ft in a darker gray zone (possible increased organic content). Thin laminae are well-preserved at the top (Fig. 2-4). The contact between M-2 and Culebra was recovered as continuous core, and the contact is sharp and undeformed (Fig. 2-4).

Figure 2-3 (left) Lower M-2/H-2 at SNL-6A

Figure 2-4 (below) Thin, Undeformed Laminae in Uppermost Los Medaños Member from SNL-6A

2.2.1.2 Culebra Dolomite Member

Based on drilling depths available at the time, the recovered Culebra core from SNL-6A was marked from 1,346.6–1,323.8 ft bgl (as used in information in Appendices C and F). The density log recorded the base of Culebra at 1,346.5 ft bgl and the top at 1,324 ft bgl (Fig. 2-1). Recovered Culebra core (Fig. 2-5) totals 22.8 ft thick, and this represents all of the unit.

Holt and Powers (1988) found a range of 20–30 ft thickness in Culebra cores described from the WIPP Project, and a regional thickness exceeding 40 ft, based on geophysical log data. Significant core loss in the middle of the Culebra is common. Complete recovery of core at SNL-6A is likely due to very limited porosity with halite fillings. Drilling using circulating brine may also have contributed to complete recovery.

The dolomite recovered in core from SNL-6A is generally light brownish gray (2.5Y6/2) to white (~2.5Y8/1). The Culebra at SNL-6A is thin bedded to laminar (Fig. 2-5) throughout. In the lower 4 ft, bedding is slightly inclined to cross-cutting. Bedding from ~1,342.4–1,336 ft shows more planar bedding and truncated upper surfaces to sets that are ~1 inch thick. The upper 3 ft of this interval are also sandier. From 1,336–1,335 ft, coated grains or oölites appear to be present, as well as very small anhydrite nodules. From 1,335–1333.8 ft, the interval is sandy, bedding is somewhat less visible, some pelecypod fragments are present, and there is possible bioturbation. From 1,333.8–~1,330 ft, bedding is thin and subhorizontal, with less distinct textural changes between thin beds. From 1,330–1,325 ft, thicker beds of fine light gray dolomite are separated by thin beds or laminae of darker gray, silty dolomite that is commonly wavy or undulatory. From 1,325–1,323.8 ft, bedding is more distinctive upward to a zone of thin, slightly wavy, possibly organic-rich laminae. The upper contact is a short interval of more wavy interbedded anhydrite and dolomite transitioning to dominantly anhydrite.

No open vugs were observed, and very few pores filled with anhydrite were observed.

Vertical to sub-vertical, planar to irregular, fractures filled with halite occur from 1,342 ft to near the base of the Culebra. Additional irregular, subvertical fractures filled with halite occur mainly between 1,337–1,335 ft, with a few above 1,335 ft. The fractures have small separations.

The hydrostratigraphic units proposed for the Culebra by Holt (1997) are not easily correlated with the core from SNL-6A, and they have not been marked on Figure 2-5. Possible correlations are presented in the next paragraph.

The most likely equivalent to the basal CU-4 hydrostratigraphic unit occurs from 1,346.6–1,342.4 ft. The interval from 1,342.4–1,336 ft may represent CU-3. The bioturbated and bedded unit from 1,336–1,333.8 ft may be the equivalent to CU-2. The upper bedded zone from 1,333.8–1,323.8 ft may be equivalent to CU-1. There is a big difference between the middle hydrostratigraphic units (CU-3 and CU-2) in thickness and characteristics as proposed by Holt (1997) based on cores obtained nearer the WIPP site and SNL-6A. There is virtually no vuggy porosity or filled vugs at SNL-6A compared to the strongly vuggy zones nearer WIPP.

The geophysical logs (Fig. 2-1) of the Culebra provide a few additional details of the unit. Resistivity remains generally low through the Culebra relative to the overlying anhydrite and salt of the Tamarisk. This is likely due to some brine along the fractures in the bed. The density log shows high density throughout, with a modest increase from ~1,332–1,330 ft. Core observations of dolomite and minimal anhydrite are consistent with the log results. The natural gamma log could not be obtained. Overall, there is not a great contrast in log properties through the Culebra, and the Culebra is likely to have very low porosity and transmissivity based on log and core observations.

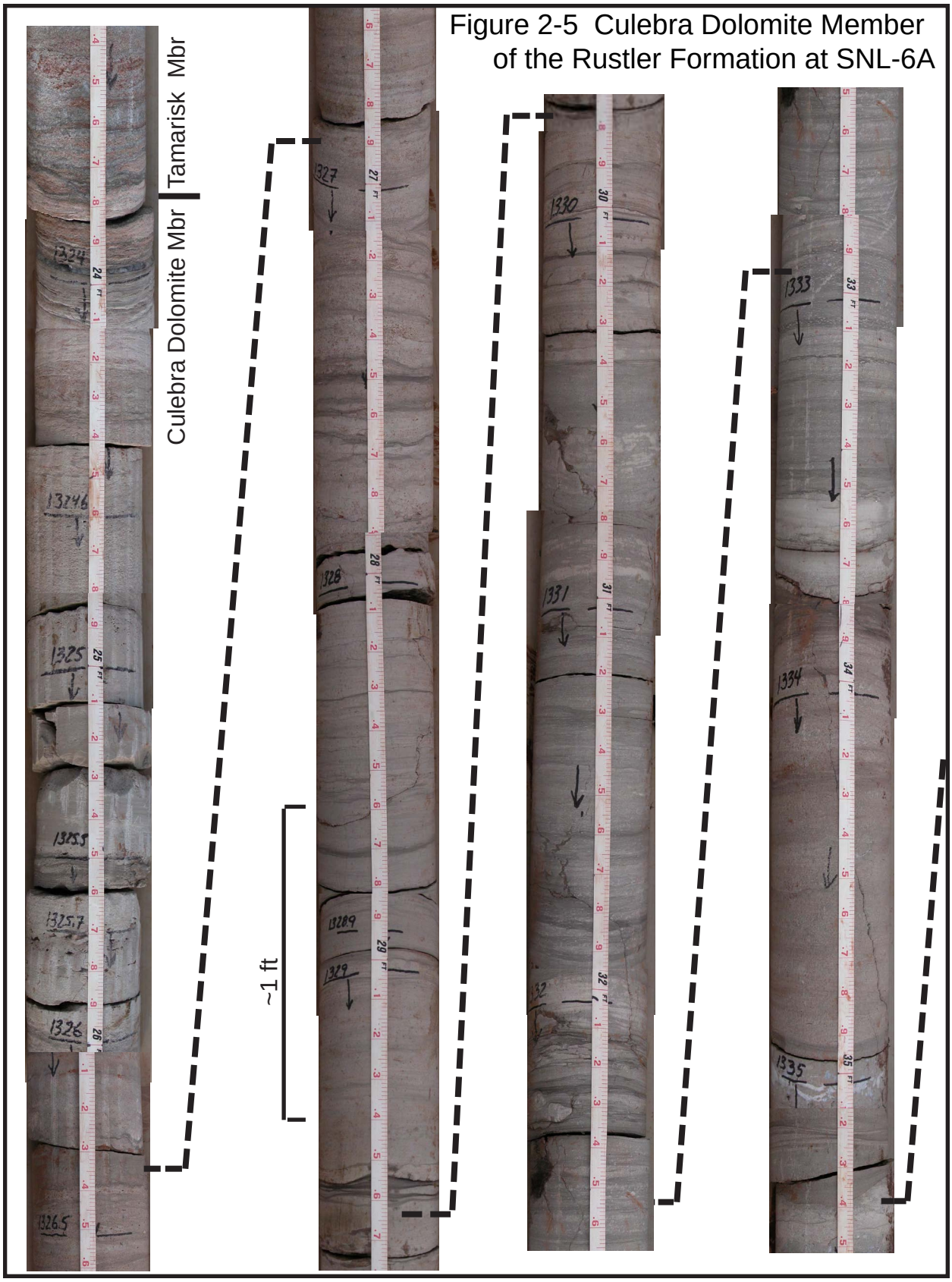
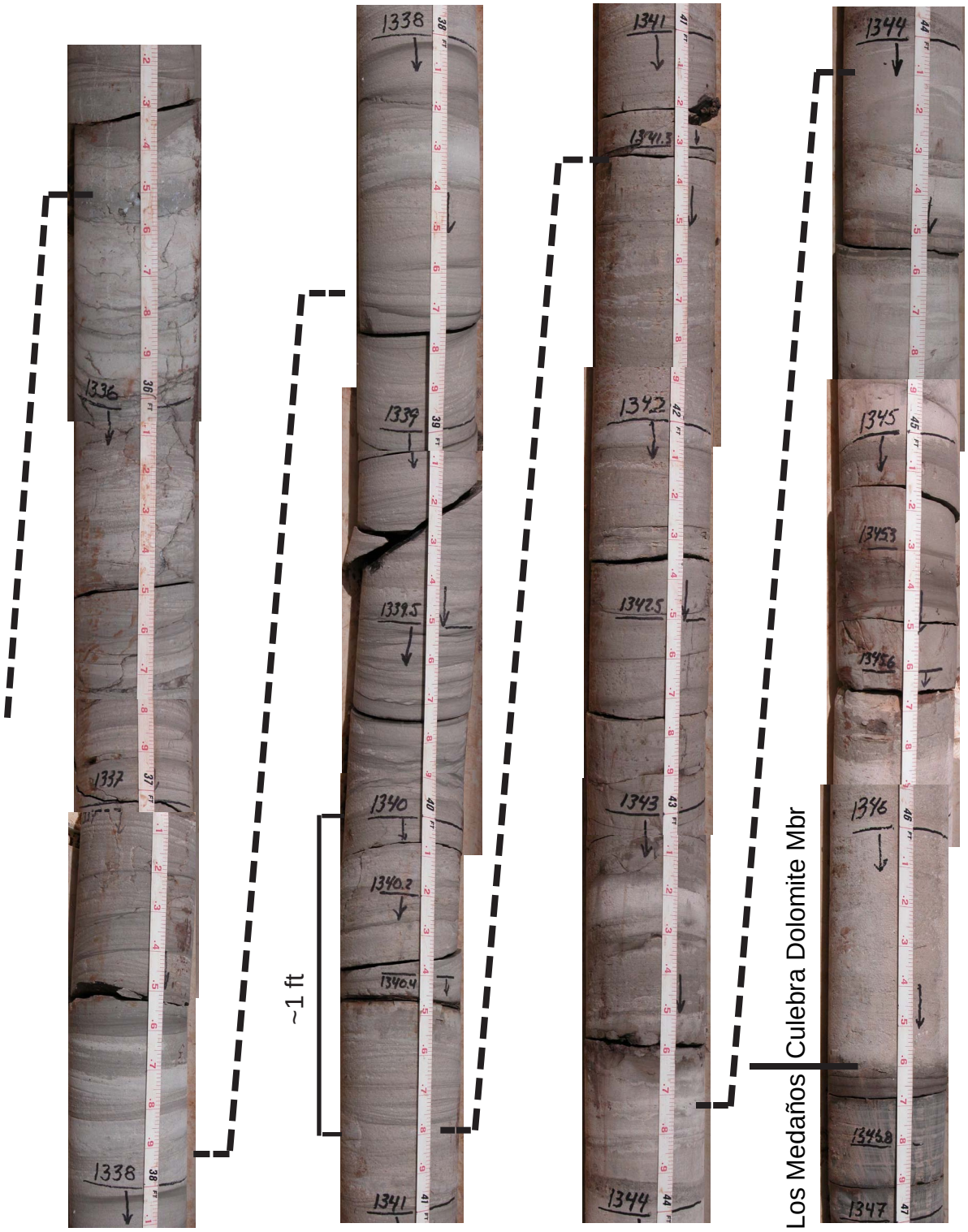


Figure 2-5 Culebra Dolomite Member of the Rustler Formation at SNL-6A

Figure 2-5 continued



2.2.1.3 Tamarisk Member

The density log of SNL-6A shows that the Tamarisk occurs from 1,324–1,129 ft bgl. The Tamarisk comprises three basic subunits: a lower anhydrite, a middle halite and mudstone, and an upper anhydrite. All three are clearly shown by geophysical logs and were recorded by cuttings and cores during drilling. Powers and Holt (2000) labeled these A-2, M-3/H-3, and A-3, respectively, and showed that the lateral gradation from mudstone M-3 to halite H-3 generally reflects lateral changes in deposition. SNL-6A is located mainly in the H-3 facies (halite pan environment) of these beds. The lower 15 ft of M-3/H-3 werecored in addition to all of A-2; the remainder of the unit is described on the basis of cuttings and geophysical logs.

The informal unit *anhydrite 2* (A-2; Fig. 2-2) at the base of the Tamarisk is 17 ft thick (1,324–1,307 ft) based on the geophysical logs (16.5 ft based on marked core depths of 1,323.8–1,307.3 ft). A-2 is predominantly medium gray anhydrite (Fig. 2-6). It is generally fine to medium grained, with prominent laminae and thin beds from 1,323.8–1,313.5 ft. Interlaminated carbonate and anhydrite near the base of this interval are wavy and may be stromatolitic. Halite and anhydrite pseudomorphs after very large vertical gypsum crystals are present from 1,313.5–1,311 ft (Fig. 2-6, labelled "S"). Some crinkly bedding may indicate pseudomorphs of gypsum swallowtails. There are some thin bedded zones with a nodular appearance, called "bedded nodular" by Holt and Powers (1988).

A-2 is divided here, as in most locations, by gray claystone or siltstone from 1,314.2–1,313.9 ft, underlain by interbedded anhydrite and siltstone. The sharp basal contact at 1,314.2 ft appears subparallel with bedding. This claystone is laminar and somewhat undulatory at the sharp transition to the overlying part of A-2.

The upper boundary of A-2 is undulatory over relief of ~0.15 ft.

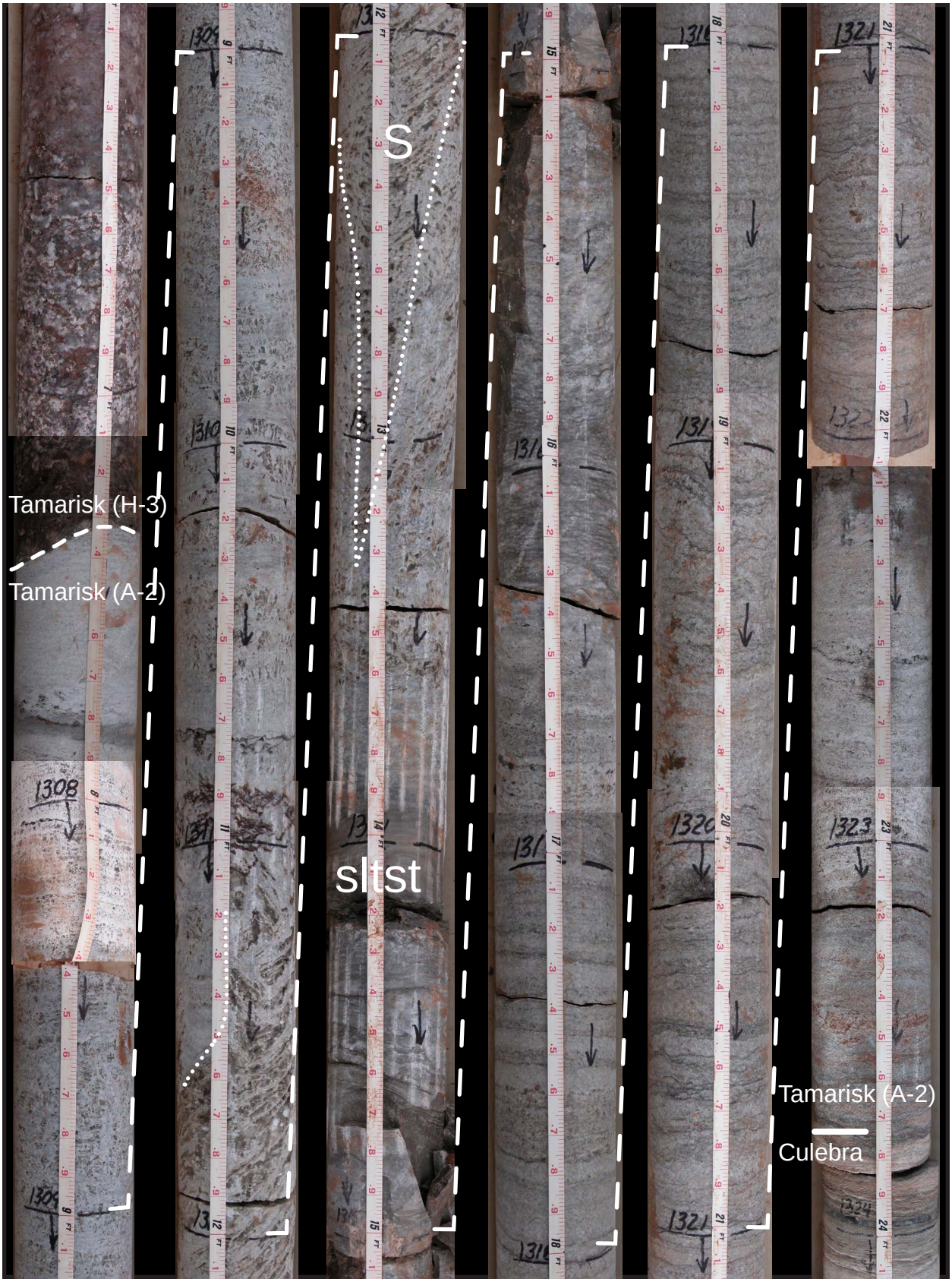
The informal unit *mudstone-halite 3* (M-3/H-3; Fig. 2-2) at SNL-6A is 131 ft thick (1,307–1,176 ft bgl), based on the density log. Core was obtained from the lower 15.3 ft. Cuttings, logs, and cores indicate that mainly halite pan deposits (H-3) are present. Sulfate beds included are characteristic of thicker H-3 deposits in southeastern NM.

The geophysical log (Figs. 2-1, 2-2) for M-3/H-3 illustrates subdivisions described by Holt and Powers (1988). They divided H-3 at the base of the sulfate bed near the middle of H-3 (1,264–1,256 ft) into a lower H-3a and an upper H-3b. H-3a can be further subdivided into a lower clean halite, middle argillaceous halite, and upper clean halite below the sulfate bed.

H-3a at SNL-6A exhibits only the lower clean halite (1,307–1,278 ft) and middle argillaceous halite (1,278–1,264 ft), similar to other drillholes (e.g., SNL-15, Powers and Richardson, 2008; also, Holt and Powers, 1988) away from the middle of the halite salt pan.

The density log indicates higher density sulfate from 1,264–1,256 ft, with cuttings indicating the bed is mainly polyhalite. The remainder of H-3b is halite with two thin interbeds of high-density sulfate, which isconsistent with units that are persistent through the deeper part of the depositional basin east of WIPP.

Figure 2-6. Tamarisk A-2 Core from SNL-6A. Depth of A-2 from 1323.8–1307.3 ft. Note the thinner parallel to undulatory bedding below 1,316 ft and the thin siltstone (sltst) at 1,314 ft. Above the siltstone, there is a large gypsum crystal (labeled "S" for "swallowtail") partially replaced by halite, with the sulfate altered to anhydrite. Above 1,312 ft, bedding is more laminar, with small halite pseudomorphs after gypsum along flat to undulatory bedding planes. The uppermost anhydrite is dense, with little evidence of bedding. The contact with halite (H-3) is undulatory and likely erosional.


S
Tamarisk (H-3)
Tamarisk (A-2)
sltst
Tamarisk (A-2)
Culebra

The core from H-3a consists mainly of fine to very coarse halite that is clear to brownish. Beds or intervals of halite become finer upward and more opaque; clay and silt content also increases upward. Thin zones of sulfate or reddish brown silt and clay overlie the top of some of these beds or intervals, and the repeated beds and features indicate thin desiccating upward intervals (Fig. 2-7).

The informal Tamarisk unit *anhydrite 3* (A-3; Fig. 2-2) at SNL-6A is 47 ft thick (1,176–1,129 ft bgl) based on geophysical logs. The unit was not cored.

A-3 is represented by gray to white anhydrite; cuttings were fine and showed no additional features. The density log shows anhydrite values, with some detailed log features that are similar to regional features found by Holt and Powers (1988). The contact with the Magenta is sharp in the log.

2.2.1.4 Magenta Dolomite Member

Based on geophysical logs, the Magenta at SNL-6A is 23 ft thick (1,129–1,106 ft), while cored thickness is 20.5 ft (1,128-1,107.5 ft). The base of the Magenta was not cored.

The Magenta (Fig. 2-8) is a gypsiferous, sandy dolomite bed of light olive gray (5Y6/2) to light gray (5Y7/2) tending upward to light brownish gray (2.5Y6/2) in core. The Magenta is well-bedded, showing a variety of forms from the base to top. From 1,128–1,124.9 ft, laminae are subhorizontal to wavy, with slight cross-cutting

Figure 2-7. Short Desiccating-upward Cycle in H-3a. Coarse halite at 1,397.8 ft becomes finer upward. A thin reddish brown siltstone at 1,397 ft rests on an undulatory surface and is overlain by coarse halite with little clastic content.

boundaries. From 1,124.9-1,119.8 ft, laminae are near horizontal to wavy, in thin sets with cross-cutting boundaries and in some ripples. From 1,119.8–1,115.1 ft, the laminae sets are thicker and cross-cutting boundaries are stronger and have relief of 0.5–1 inch. Larger ripples, with cross-beds 0.5 inch high, are also present. From 1,115.1–1,114.8 ft, the dolomite is coarser and sandier, and may show halite replacement of small grains or oölites. The erosional surface at the base of this thin interval shows ~2 inches of relief. A thin organic layer lamina overlies a thin (<0.25 inch) halite at the top of this interval. The interval from 1,114.8–1,111.1 ft is similar to the interval just below 1,115.1 ft. From 1,111.1–1,109.8 ft, dolomite is in starved ripples in subhorizontal beds that include organic-rich clay laminae up to 0.125 inch in thickness and some small gypsum nodules. From 1,109.8–1,107.5 ft, the bedding is planar to slightly wavy with low angle cross-cutting relationships and no apparent ripples.

Tiny (~0.l25 inch) white grains or nodules of possible gypsum occur at 1,128–1,124.0 ft and 1,120.3–1,119.8 ft, with slightly larger (<0.25 inch) similar grains from 1,111.1–1,109.8 ft.

There are a few thin, irregular, halite-filled fractures above 1,115 ft. The most visible are just below 1,109 ft.

Geophysical log data from the Magenta show lower density than the adjacent anhydrite beds with the lowest density zone in the middle of the member. Resistivity decreased through the Magenta compared to the underlying anhydrite and halite beds. Similar to the Culebra, there may be some brine in limited porosity that decreases the resistivity. Whether this is formation fluid or drilling fluid is undetermined.

2.2.1.5 Forty-niner Member

Based on geophysical logs, the Forty-niner at SNL-6A is 61 ft thick (1,106–1,045 ft). Much of the lower Forty-niner is described from the core, while the upper anhydrite is partially described on the basis of cuttings and geophysical logs. Like the Tamarisk, the Forty-niner consists of upper and lower anhydrites with a middle unit that is mainly halite with some mudstone at SNL-6A. Powers and Holt (2000) informally designated these units as A-4, M-4/H-4, and A-5, from bottom to top. They attributed the lateral relationship between clastic beds (M-4) and halite (H-4) to depositional facies of mudflat–saline mudflat–saltpan environments.

The lower unit, *anhydrite 4* (A-4; Figs. 2-2, 2-9), is gray anhydrite. A-4 is 14 ft thick (1,106–1,092 ft), based on geophysical logs, and is 12.9 ft as marked on core (1,107.5–1,094.6 ft). The anhydrite is medium to dark gray and it shows common bedding, including carbonate laminae. A zone near the middle and a zone near the top of A-4 display small, vertical gypsum crystal growth as well as halite pseudomorphs after such crystals. There are some apparent sulfate nodules in the lower 3 ft, mainly as the bedded nodular texture. The upper boundary of A-4 is sharp and probably erosional.

Mudstone-halite 4 (M-4/H-4; Figs. 2-2, 2-9, 2-10) is about 18 ft thick (1,092–1,074 ft), based on the density log as well as the coring record. The basal contact in core was marked 1,094.6 ft, and the upper contact was marked 1,076 ft. There was some core loss attributed to the upper part of M-4/H-4. Core and geophysical log data indicate that this interval is dominated by halitic facies, while clastics dominate in the lower 1.3 ft and the upper ~1-2 ft recovered.

The basal siltstone is gray (5Y6/1), non-calcareous, and moderately indurated. It displays laminar bedding with slightly cross-cutting set boundaries. Some white gypsum is preserved at 1,093.8 and 1,093.4 ft subparallel to bedding. A fracture near the top of the gray siltstone is inclined ~45° from horizontal, has a narrow aperture, and is filled with halite.

Halite from 1,093.3–1,088.3 ft is medium to very coarse, generally clear with some fine

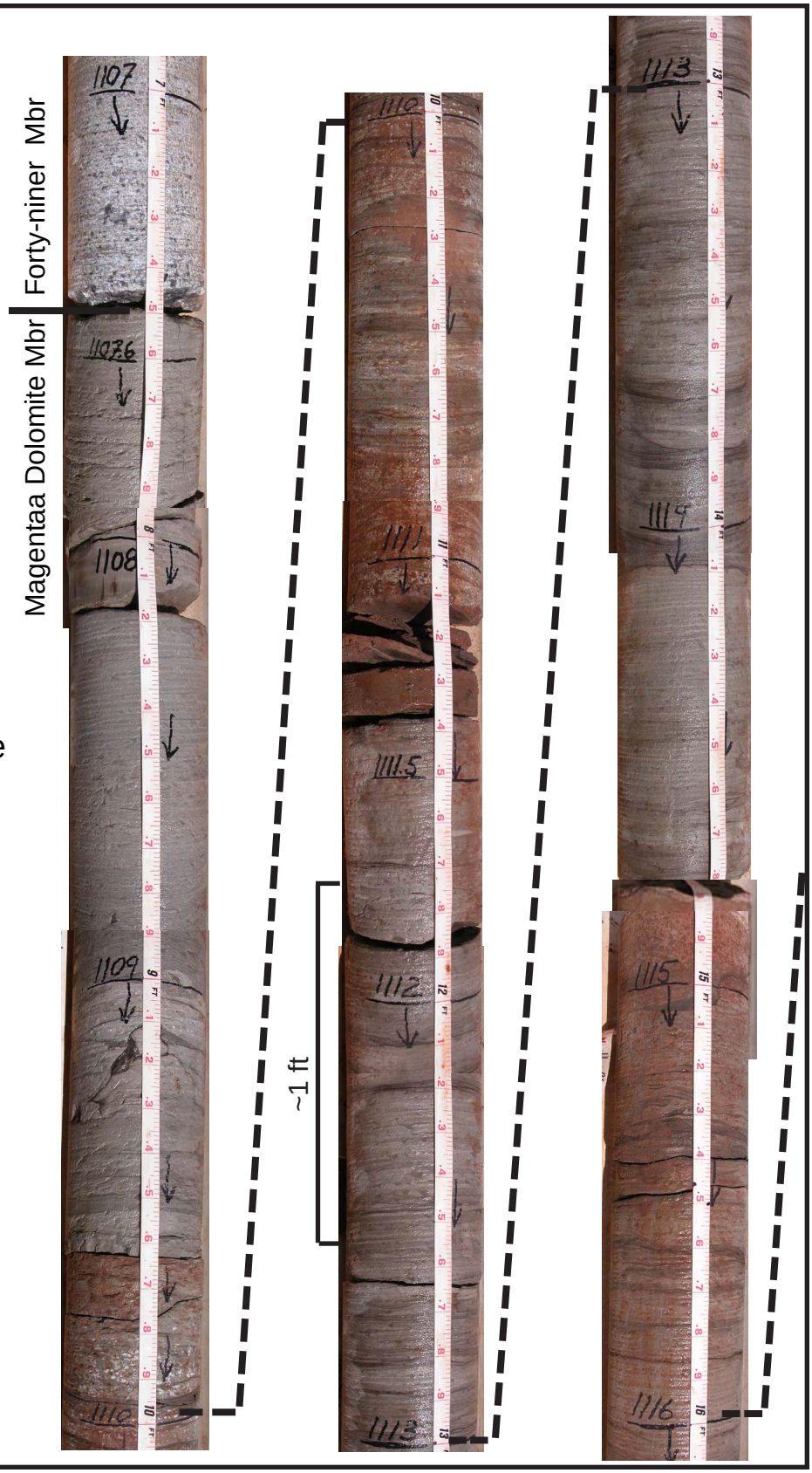


Figure 2-8
Magenta Dolomite Member of the Rustler Formation at SNL-6A

Figure 2-8 continued

brownish halite. Gray siltstone is common in intercrystalline spaces as well as some subhorizontal zones. Some halite shows well-developed displacive margins. There are poorly developed possible corrosion surfaces in the interval.

From 1,088.3–1,084 ft, the halite is fine to very coarse, generally clear but with a slight brownish tint. This interval shows reddish brown siltstone in intercrystalline spaces, and the halite in the lower part of the zone shows some well-developed displacive margins. Corroded margins increase upward, as does the proportion of siltstone.

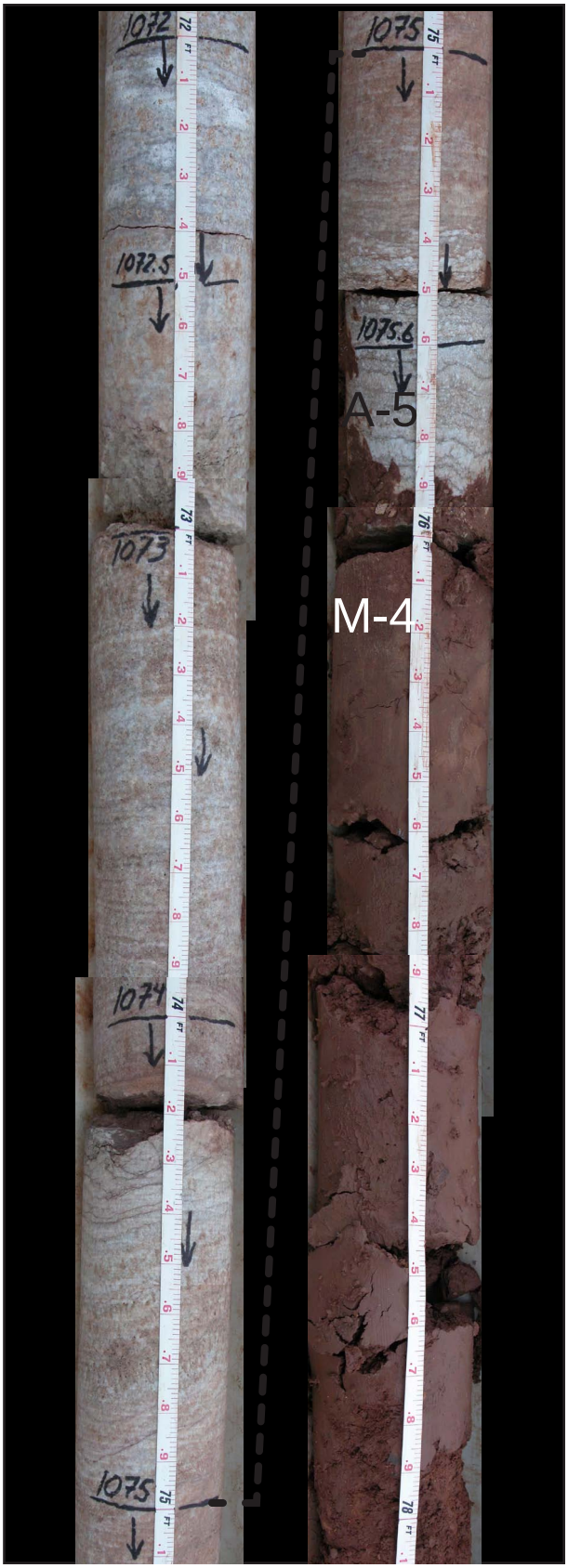
From 1,084–1,083.5 ft, a dark reddish brown (5YR3/3; damp) argillaceous siltstone includes some halite. This thin interval is softer.

The argillaceous siltstone attributed to the upper part of M-4/H-4 is similar to the argillaceous siltstone at 1,084 ft, although there is no halite apparent in the upper siltstone. The siltstone was attributed to the interval from ~1,078–1,075.9 ft.

The upper sulfate unit, *anhydrite 5* (A-5), is light gray to white fine anhydrite that is 29 ft thick (1,074–1,045 ft bgl) at SNL-6A based on geophysical logs. Core was taken from the lower 5.9 ft. The core shows well developed laminar bedding <0.5 inch in thickness with some bedding ~1 inch thick. Some of the subhorizontal planes may be stylolitic. Halite pseudomorphs after bottom grown gypsum at 1,074.7 ft show growth on a curved ridge-like substrate. Small nodules and bedded nodular textures are visible

Figure 2-9. Lower Sulfate to Mudstone/ Halite Unit of Forty-niner Member of the Rustler Formation.

The upper 3–4 ft of A-4 displays laminar to thin bedding with undulatory growth surfaces. The transition to the mudstone/halite unit shows a laminar gray siltstone overlain by muddy halite with displacive growth.



near the base of A-5. The core does not show any signs of brecciation or fracturing that would indicate solution of underlying halite after A-5 became indurated.

Drilling rates changed at ~1,046 ft bgl, which is consistent with the log interpretation of the top of the Rustler. The upper contact with the Dewey Lake Formation appears to be sharp in geophysical logs.

2.2.2 Permo-Triassic Dewey Lake Formation

The Dewey Lake Formation has most commonly been assigned to the Permian System (e.g., Hills and Kottlowski, 1983), although there is no direct evidence, either paleontological or radiometric, of age in the vicinity of WIPP. More recently, Renne and others (1996, 2001) obtained radiometric (Ar-Ar) ages from ash beds near the base of lithologically equivalent red beds (Quartermaster Formation) in the Texas panhandle. These ages show that the basal Quartermaster is Permian, but most of the formation is early Triassic in age. Although lithologic contacts are not inherently isochronous, the particular relationships of evaporites to red beds suggest that the Dewey Lake is mainly Triassic in age (e.g., Schiel, 1988, 1994; Powers and Holt, 1999). Lucas and Anderson (1993) have asserted that the Quartermaster, and Dewey Lake, are Permian in age, but more recent direct evidence supersedes their discussion.

Figure 2-10. Upper M-4/H-4 Transition to A-5 of Forty-niner Member of the Rustler Formation. The upper 3–4 ft of M-4 is soft and does not display visible bedding on the surface. The lower A-5 shows laminae and thin bedding that is subhorizontal to horizontal, with undulatory growth surfaces.

At SNL-6A, the Dewey Lake is 499 ft thick (1,045–546 ft bgl) based on the density log; logged cuttings indicated a change when drilling reached a depth of 558 ft (Appendix C). The Dewey Lake is composed mainly of weak red (2.5YR4/2) interbedded sandy siltstone, argillaceous siltstone, and fine-grained sandstone. Small white (5Y5/1) reduction spots and zones are a common characteristic of the Dewey Lake and are recorded by the cuttings at SNL-6A. The Dewey Lake is calcareous only near the top. Below 590 ft, Dewey Lake cuttings include gypsum, mainly represented by fibrous gypsum. Larger cuttings at 680 ft showed poikilotopic gypsum cements. The Dewey Lake is described on the basis of cuttings and geophysical log characteristics.

Geophysical logs from SNL-6A can be partially interpreted to indicate different basic sedimentary regimes as well as porosity conditions (e.g., Doveton, 1986). The following information follows the basic template developed for a study of the Dewey Lake hydrogeology (Powers, 2003b) and applied to other drillholes such as C-2737 (Powers, 2002b) and SNL-2 (Powers and Richardson, 2004).

Two of three general depositional regimes for the Dewey Lake can be more readily distinguished on the density log of SNL-6A; the upper regime is not distinct and is usually defined by decreasing natural gamma, a log not acquired at SNL-6A because of hole conditions.

The interval from 1,045–~920 ft bgl in SNL-6A displays variable density that is likely equivalent to the informal *basal bedded zone* (Powers, 2003b). The natural gamma log from the nearby oil well (API# 30-025-27603) is consistent with this interpretation. The resistivity also changes above this interval.

The interval from ~920 to ~630 ft bgl appears to have slightly higher resistivity. The nearby oil well shows a similar interval marked by generally upward-increasing gamma above thinner low-gamma units. The highest gamma measured in the oil well is at 600 ft. The density shows some difference at 650 ft. This interval (~290 ft) is likely equivalent to an interval of *fining-upward cycles* because increasing natural gamma is frequently an indicator of finer clastic grain sizes (Doveton, 1986; Powers, 2003b). Near the center of the WIPP site, this interval is more than 300 ft thick; at C-2737 it was 260 ft thick (Powers, 2002b). West-southwest of WIPP, sandstones of the upper fining-upward cycles are removed by erosion.

Above 650 ft, density is slightly less than in the underlying beds, and resistivity also is lower above 630 ft. The natural gamma in the adjacent oil well shows modestly decreasing natural gamma that indicates coarsening upward as proposed by Powers (2003b). The contact with the Dockum at 546 ft based on changes in density is near the depth where interbedded sandstones and siltstones begin to dominate.

The natural gamma log in the nearby oil well shows a sharp decrease at 697 ft that corresponds to sandstone 1 (*ss1*), a persistent sandstone in this stratigraphic interval (Powers, 2003b). The sand grains in cuttings from other wells at depths with this log signature are subround to round. The cuttings log from SNL-6A shows a sandstone with rounded grains from ~700–680 ft that is correlated with *ss1*. The sandstone is well cemented with sulfate. The geophysical logs from SNL-6A do not show a clearly distinguishable signature for this sandstone.

By comparison with other drillholes, the Dewey Lake is likely to be poorly transmissive because of extensive sulfate cements.

2.2.3 Triassic Dockum Group

The redbed formations (Dockum Group) above the Dewey Lake at SNL-6A are poorly differentiated by logs (lack of natural gamma) and cuttings. In figures and tables, this interval is referred to as Dockum Group undivided. As a first approximation of stratigraphic subdivisions, however, I tentatively assigned the top of

Santa Rosa Formation at 296 ft (Fig. 2-1) based on log signature changes as well as coarser sediments at ~300 ft (Appendix C).

The Santa Rosa at SNL-6A is 250 ft thick (546–296 ft) based on this assignment. The Santa Rosa is mainly sandstone that is moderately indurated and interbedded with siltstone. The Santa Rosa shows a variety of colors such as weak red (2.5YR5/2; 7.5R4/2), light red (2.5YR6/6), reddish brown (2.5YR4/4) and white (5Y8/1). The sandstone includes mica and coarser grains. The lower ~200 ft of the Santa Rosa is generally slightly calcareous, while the upper part is commonly very calcareous.

Cuttings from the Santa Rosa were slightly moist beginning at ~380 ft, and were sufficiently moist to begin caking at 400 ft. The decision was made at 416 ft to begin using mist, and the drillhole produced water from the Santa Rosa (see section 3.0).

From 296–57 ft, Dockum Group sediments are finer and could be assigned to the Tecovas Formation. This is not being done formally here because of the uncertainty in geophysical log signatures and cuttings with respect to regional data.

These tentative correlations and overall use of Dockum Group follow the discussion of Lehman (1994) rather than the many stratigraphic units and changes of names proposed by Lucas and colleagues (e.g., Lucas, 2004).

2.2.4 Miocene-Pleistocene Gatuña Formation

The Gatuña is 27 ft thick (57–30 ft). It is reddish brown sand or poorly indurated sandstone that is more argillaceous in the lower 10 ft. Chert and quartz pebbles were encountered at a depth of ~40 ft.

Powers and Holt (1993) reported regional geological descriptions and interpretations of Gatuña depositional environments.

2.2.5 Pleistocene Mescalero Caliche

The Mescalero is an informal soil stratigraphic unit defined by Bachman (1973). It is widespread in southeastern NM, and it is a continuous stratigraphic unit at the WIPP site. Uranium-disequilibrium ages indicate the Mescalero formed as a pedogenic unit between ~570,000 (± 100,000) and about 420,000 (±60,000) years ago (Rosholt and McKinney, 1980). The age is further bounded by the Lava Creek B ash, about 600,000 years old, which underlies the Mescalero along Livingston Ridge (Izett and Wilcox, 1982).

At SNL-6A, the Mescalero is 6 ft thick (30–24 ft) based on cuttings. The Mescalero is a pale brown (10YR6/3) to very pale brown (10YR8/3), very calcareous sandstone to sandy limestone. The cuttings were generally well indurated and show developed laminae. The unit becomes less calcareous with depth. Sand grains are fine to very fine and subrounded.

Bachman and Machette (1977) classified six useful stages of pedogenic calcrete development, ranging from I as the least developed to VI morphologies showing multiple generations of calcrete development. ("Pedogenic calcrete" is preferred by many geologists and pedologists over the term "caliche" because of the wide variation in use of the latter term.) The Mescalero at SNL-6A is classified as Stage IV or higher.

2.2.6 Surficial Deposits

Construction fill and sand is up to 24 ft thick at the drillhole location. The Berino soil (Chugg and others, 1971) was encountered at SNL-6A at 15 ft. It is mainly sand, with some clay content and some black stains (possible MnO).

The dune sand from 15–6 ft is red (2.5YR5/6; moist), damp and malleable, very calcareous, very fine to medium, and subangular to subround, with 1–2% opaques and some MnO stains.

The material from 6 ft to surface reflected a mix of drill pad caliche and dune sand.

Wildflowers near SNL-6, September 10, 2005. Photographs by Dennis W. Powers.

3.0 PRELIMINARY HYDROLOGICAL DATA FOR SNL-6A AND SNL-6

SNL-6 was drilled specifically to monitor water levels from the Culebra Dolomite Member of the Rustler Formation near the northeast corner of the hydrologic modeling domain. SNL-6A was the original well drilled that had to be plugged and abandoned because of difficulties while trying to complete the well. Shallow groundwater data come from SNL-6A.

3.1 Checks for Shallow Groundwater Above the Rustler Formation

SNL-6A was drilled with compressed air to 416 ft. Mist was used from 416 ft to 1,112 ft, and circulating brine was used below 1,112 ft. Moist cuttings were encountered ~380 ft bgl.

Table 3-1 summarizes observations of water levels while the bottom of the drillhole was in the lower Dockum, Dewey Lake, and upper Rustler.

On July 11, 2005, water was blown from the drillhole at the end of drilling (497 ft depth). Early July 12, 2005, the water level was 375.11 ft below the cement pad level. The measurement indicates the elevation of the top of water was ~996.1 m amsl; assuming little water remained in the hole, calculated inflow was 0.7 gallons per minute (gpm) (Table 3-1). The drillhole was entirely in the Dockum during this observation.

On July 12-13, 2005, a similar set of observations with the drillhole at 712 ft (upper Dewey Lake) provided an estimate of 1.1 gpm flow and a fluid elevation of 959.1 m amsl at the time of observation (Table 3-1).

On July 14, 2005, following another overnight shutdown at a depth of 875 ft (Dewey Lake), the estimated fluid flow was 1 gpm, and fluid elevation was 898 m amsl.

These three observations are consistent with fluid production of ~1 gpm from the lower Dockum and a potentiometric surface of ~996 m amsl (no production from the Dewey Lake).

Table 3-1
Groundwater Inflow Measurements at SNL-6A

Measurement Date/Time	Shut Down time & day previous	Depth to Water below pad level	11"Hole Depth at Measurement	6.75" Hole Depth at Measurement	Water Column (ft)	Water volume in ft^3	Water Volume in gallons	Hours	Water rise (ft/hr)	GPM	Approx wl elev (m)[5]
7/12/05 7:45	7/11/05 17:15	375.11[1]	497	497	121.89	80.4	601.8	14.5	8.4	0.7	996.1
7/13/05 8:10	7/12/05 16:10	496.25[2]	712	712	215.75	142.4	1,065.2	16.0	13.5	1.1	959.1
7/14/05 8:10	7/13/05 17:15	696.95[3]	875	875	178.05	117.5	879.1	14.9	11.9	1.0	898.0
7/15/05 6:30	7/14/05 14:58	897.7[4]	1,070	1,070	172.3	113.7	850.7	15.5	11.1	0.9	836.8
7/18/05 8:00	7/15/05 11:50	399.8[4]	1,070	1,098	670.2	449.3	3,360.9	68.2	9.8	0.8	988.5

[1]Water level measured with drill pipe and bit in hole to TD
[2]Water level measured with drill pipe and bit in hole to ~615 ft
[3]Water level measured with drill pipe and bit in hole to 717 ft
[4]Water level measured with no drill pipe or bit in water
[5]Ground level elevation is ~3,643 ft amsl (1,110.4 m)

A grab sample of the water blown from the drillhole on the morning of July 13, 2005, yielded a field observation of specific gravity of 1.005 using an uncalibrated hydrometer. The sample may be influenced by soap or drilling mist not removed from the drillhole the prior evening.

3.2 Initial Results From the Forty-niner Member

Overnight and weekend observations of inflow to SNL-6A were obtained while the drillhole was at 1,070 ft (lower A-5) and 1,098 ft (upper A-4), respectively (Table 3-1). Mist with soap was used to drill and core to these depths.

These observations indicate flows slightly less than 1 gpm. The observation early July 15, 2005, shows a water level elevation of 836.8 m amsl after overnight recovery. This is ~160 m below the observed fluid elevation from the Dockum. The weekend observation (July 15-18) showed a fluid elevation of 988.5 m amsl, ~8 m less than for the Dockum.

Core and cuttings from the Forty-niner do not suggest any significant inflow to the drill hole. Given core and cuttings observations, similar production rates, and similar fluid levels, the Dockum was likely the only significant source of inflow.

3.3 Initial Results From the Culebra Dolomite

There were no observations of Culebra inflow in SNL-6A. The hole was drilled through the Culebra with circulating brine and was plugged and abandoned due to problems completing the well.

No observations of water or brine inflow from the Culebra were made in SNL-6 during drilling and completion. WRES began monthly water-level monitoring of the Culebra on March 13, 2007; the initial depth to water was 954.77 ft below the top of casing (Siegel, 2007).

Based on very little Culebra porosity and on halite filling fractures, SNL-6 was completed using smaller diameter FRP casing in a smaller diameter drillhole than was used in most other wells. The casing has consistent internal diameter of 2.47 inches (nominal 2.5 inches) with endcap and typical screen (Fig. 3-1).

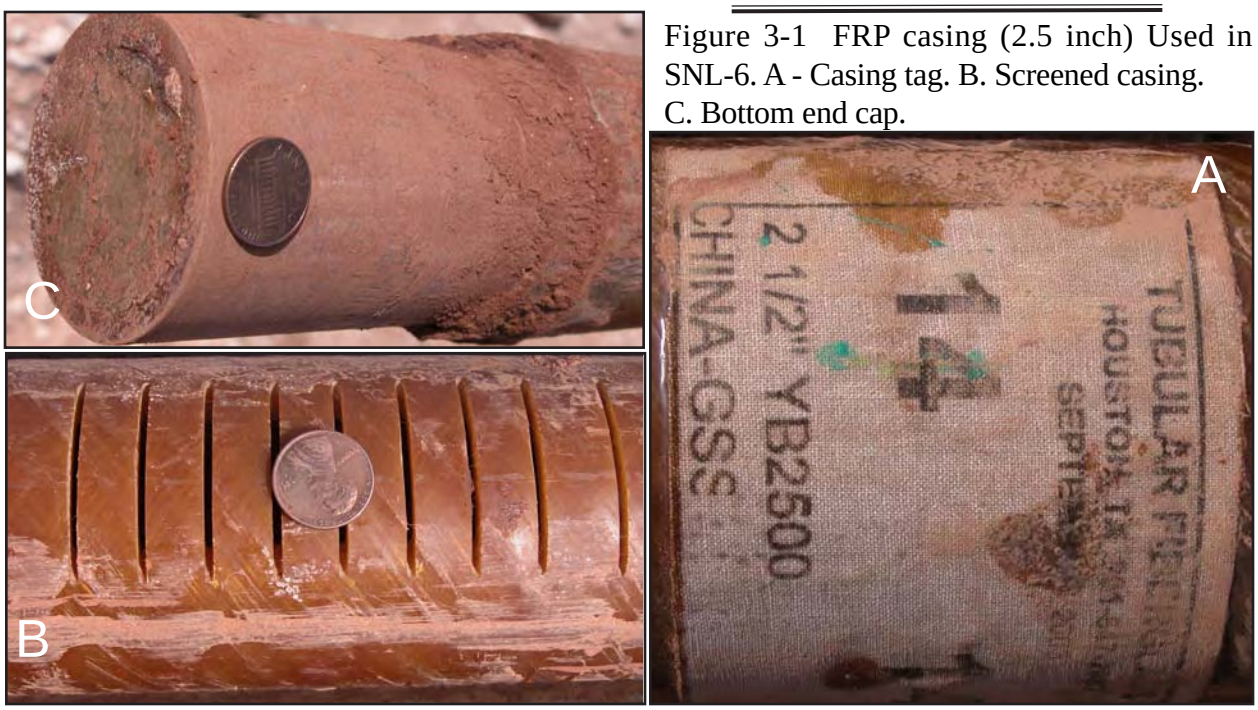


Figure 3-1 FRP casing (2.5 inch) Used in SNL-6. A - Casing tag. B. Screened casing. C. Bottom end cap.

4.0 SIGNIFICANCE/DISCUSSION

A principal condition for locating SNL-6 was to provide hydrological information in the vicinity of the northeast corner of the hydrological modeling domain (SNL, 2003; Fig. 4-1). It also provided information about conditions near some Rustler halite margins.

The lower Rustler and upper Salado were not penetrated at SNL-6 or SNL-6A. Previous studies of thickness changes between the Culebra and Vaca Triste Sandstone Member of the Salado (Powers, 2002a, 2003a, 2007; Powers and others, 2003, 2006) indicated that SNL-6 was located far east of the upper Salado halite dissolution margin and is in the area where no halite has been dissolved. SNL-6 was also located east of the margin of halite in all four M/H units of the Rustler (Fig. 4-1), although there was less certainty of the M-2/H-2 and M-3/H-3 margins based on early work. It is generally comparable to the location for the SNL-15 hydropad (Powers and Richardson, 2008).

Halite was recovered from core of M-2/H-2. The contact with the overlying Culebra showed continuous deposition and no deformation of fine laminae in the claystone immediately underlying the dolomite. The relationship was similar to that at SNL-15 where H-2 was also present. The cores from SNL-15, SNL-8, and SNL-6A are consistent with the proposal by Holt and Powers (1988) that Culebra was deposited over the gray claystone and siltstone without a hiatus. The gray claystone and siltstone were deposited across (above) the halite-pan salts in the depositional center of the basin rather than being a residue after halite was dissolved from the uppermost M-2/H-2.

Culebra core recovery was complete. This may be due to the lack of porosity at SNL-6A and the presence of halite in the few observed fractures. Compared to cores obtained south of SNL-6A, the Culebra displayed more laminae and wavy bedding here, with almost no vugs, either filled or open. At SNL-6A, the depositional environment for the Culebra appears to have been higher energy, based on bedding types, than in areas to the south; this is similar to Magenta depositional environments. The Culebra core indicates that transmissivity at SNL-6 is likely to be very low.

The basal Tamarisk anhydrite (A-2) at SNL-6A shows bedding that reflects deposition on a flat to undulatory surface. A thin gray clastic unit exists across much of the area. The upper boundary of A-2 is undulatory and likely erosional.

Thick Tamarisk halite (H-3) was present at SNL-6A. In addition, the H-3/M-3 unit showed details of deposition similar to the center of the halite pan east of WIPP, as proposed in Holt and Powers (1988), to include polyhalite and other thin sulfate beds in the upper part of H-3.

A-3 was not cored at SNL-6A. The thickness is somewhat less than in areas not underlain by H-3. The density geophysical log records detailed variations that have been noted over a much larger area (Holt and Powers, 1988).

The Magenta Dolomite is thin bedded to laminated, including some small ripples and wavy bedding. High-relief wavy beds commonly found near the base of the Magenta, and attributed to stromatolites, were not cored. Sulfate nodules commonly found in the upper Magenta are very small and minor. There is no interval of higher porosity. Halite fill in the few observed fractures, and the lack of indicators of porosity suggest that the Magenta would have very low transmissivity.

The Forty-niner at SNL-6A shows a sequence of lower and upper anhydrite beds separated by both halite and mudstone of the M-4/H-4 facies. Powers and others (2006) described the sequence as indicating an initial position within the halite pan depositional environment that was succeeded by a mudflat environment. Powers and others (2006) suggest that this represented two depositional cycles, not a single desiccating-upward sequence.

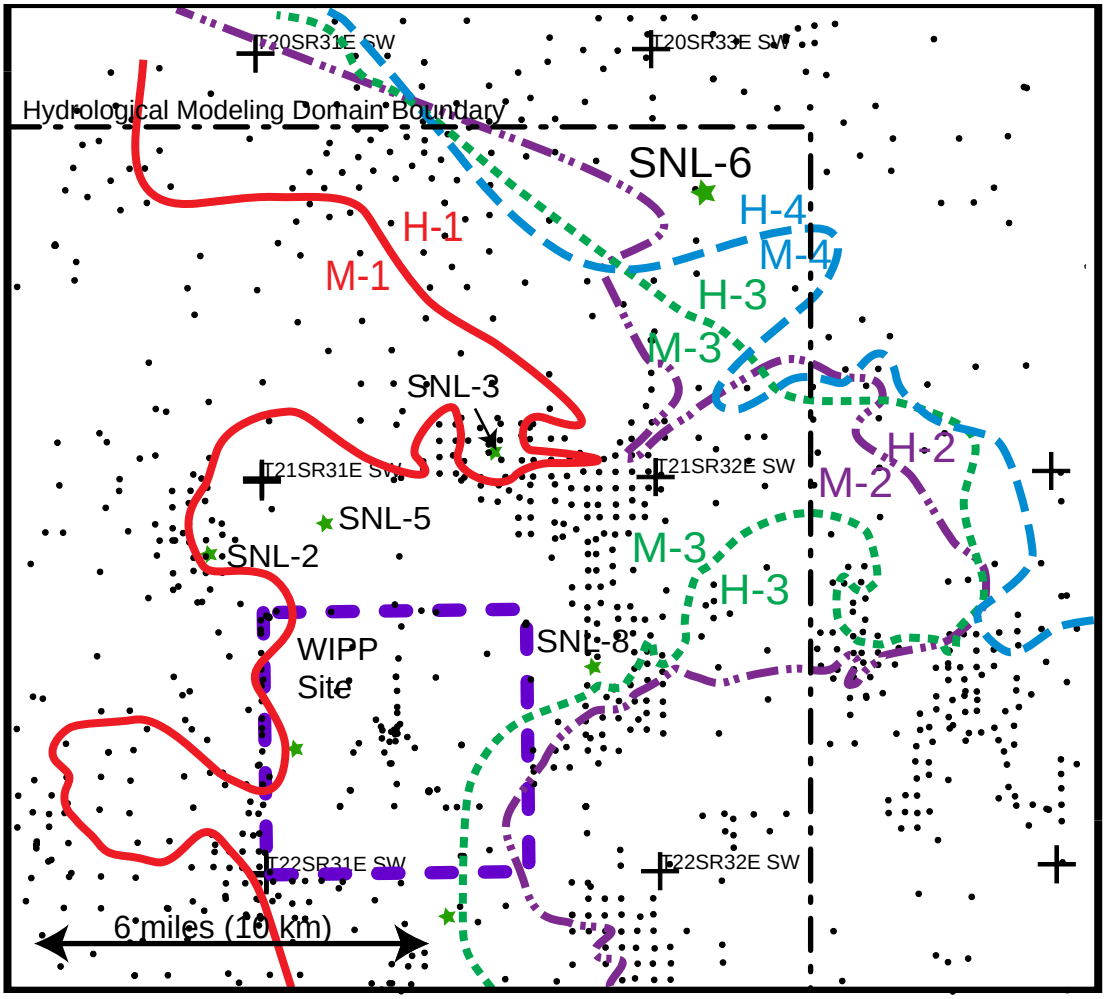
Cuttings, drilling rates, and density logs suggest that fibrous gypsum and sulfate cements

of the Dewey Lake occur through most of the formation. This uppermost sulfate is higher stratigraphically than at the center of the WIPP site (Powers, 2003b). The broad trend for this boundary is to be stratigraphically low west and south of the WIPP site center and stratigraphically higher in the center and eastern part of the site (Powers, 2003b). There does not appear to be a productive saturated zone at this boundary in SNL-6, or in any other part of the Dewey Lake.

The Dockum is thicker at SNL-6 and SNL-6A compared to most WIPP drillholes. This is consistent with eastward dip of beds and higher topography. Logs and cuttings indicate the Dockum is interbedded sandstone and siltstones. Low specific gravity water in the lower Dockum flowed at a rate estimated to be ~1 gpm; the potentiometric surface is estimated at ~996 m amsl. The measured Santa Rosa water level at SNL-8 was ~1,027 m amsl (Powers, 2009). Neither water level may have been stabilized when measured. The specific gravity for Dockum water for both locations is based on uncalibrated field measurements.

The Gatuña is 27 ft thick at SNL-6A. The formation tends to be thinner, or not exist, in the eastern part of WIPP. SNL-6A is located along the northwestern extent of the Bilbrey Basin, and the Gatuña at SNL-6 may be related to this system, including San Simon Swale.

Figure 4-1. Location of SNL-6 Relative to Rustler Halite Margins. Modified from Powers (2007). Black dots are well locations. Green stars are locations of some recent "SNL"-series wells.



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Appendix A
Drillhole Objectives

The basic document providing the basis for the drillhole and operations is the Program Plan WIPP Integrated Groundwater Hydrology Program, FY03-09 (Revision 0; Sandia National Laboratories, 2003). The main objectives are to resolve questions about water-level changes, provide data for modeling groundwater hydrology, and construct a network of wells to monitor groundwater through the WIPP operational period. Sections of this document relevant to this drillhole have been reproduced on the following pages, with the page number of the section preceding the extract and an ellipsis (…) following the end of the extracted section. A few figures have been included, but references and most figures are not included. The original document (Sandia National Laboratories, 2003) should be consulted for complete details and context for the program. Acronyms in the extracted text may not have a definition included in the extracted text.

SNL-6 was designated as a location in the original groundwater hydrology program (Sandia National Laboratories, 2003) to provide information on model boundary conditions.

The material selected here for SNL-6 represents objectives excerpted from Sandia National Laboratories (2003). In addition, some material from letter reports regarding the location has been excerpted where it is germane to SNL-6. Note that some pages reproduced here have been reduced in scale to fit the report page format.

The original location on the drilling pad had to be plugged and abandoned. It has been designated SNL-6A in this report. The second drillhole on the pad was completed and is being monitored; it is designated SNL-6.

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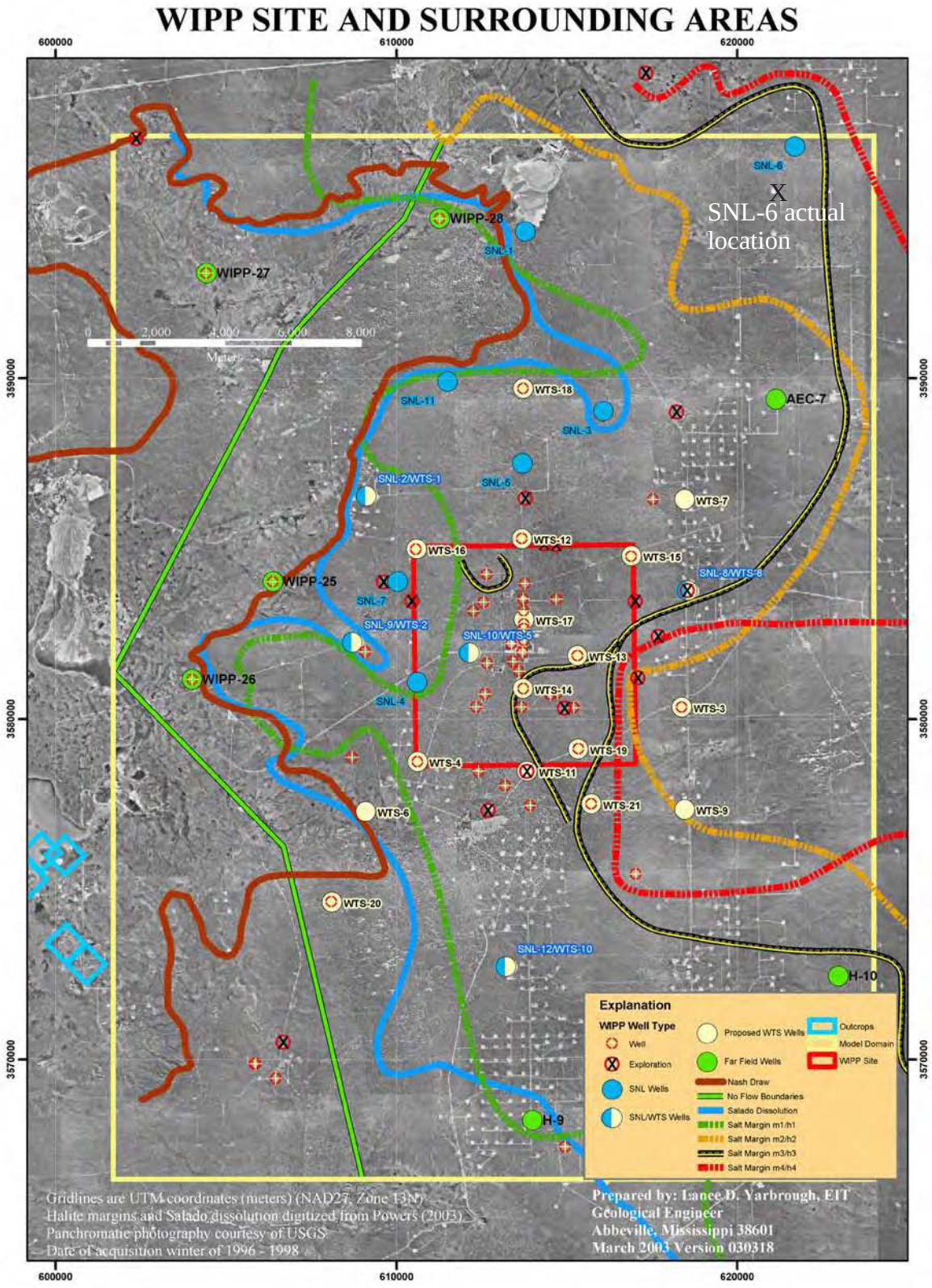
WIPP SITE AND SURROUNDING AREAS
600000
610000
620000
3590000
3580000
3570000
SNL-6
X
SNL-6 actual location
WIPP-28
SNL-1
WIPP-27
0 2,000 4,000 6,000 8,000
Meters
SNL-11
WTS-18
AEC-7
SNL-3
SNL-2/WTS-1
SNL-5
WTS-7
WTS-12
WTS-16
WTS-15
WIPP-25
SNL-8/WTS-8
SNL-7
WTS-17
SNL-9/WTS-2
SNL-10/WTS-5
WTS-13
WIPP-26
WTS-14
SNL-4
WTS-3
WTS-19
WTS-4
WTS-11
WTS-21
WTS-9
WTS-6
WTS-20
SNL-12/WTS-10
H-10
H-9
Explanation
WIPP Well Type
Well
Exploration
SNL Wells
SNL/WTS Wells
Proposed WTS Wells
Far Field Wells
Nash Draw
No Flow Boundaries
Salado Dissolution
Salt Margin m1/h1
Salt Margin m2/h2
Salt Margin m3/h3
Salt Margin m4/h4
Outcrops
Model Domain
WIPP Site
Gridlines are UTM coordinates (meters) (NAD27, Zone 13N)
Halite margins and Salado dissolution digitized from Powers (2003)
Panchromatic photography courtesy of USGS
Date of acquisition winter of 1996 - 1998
Prepared by: Lance D. Yarbrough, EIT
Geological Engineer
Abbeville, Mississippi 38601
March 2003 Version 030318

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5. Description of Field Activities

A variety of field activities are planned to address the issues discussed in Section 3 and provide data needed for the modeling activities discussed in Section 4. To the extent possible, the activities represent an integrated approach to addressing all of the issues simultaneously, rather than a piecemeal approach that addresses each issue individually. The principal components of the field activities are drilling and logging of new and replacement wells, testing in individual wells, large-scale testing involving many wells, recompletion of existing wells, and plugging and abandonment of old wells. In addition, we anticipate that various ancillary activities will be necessary to collect information to support scenario evaluation and conceptual model development. The planned schedule for the field activities, as well as for the modeling activities, is described in Section 6. The activities described below represent our best current estimate of the work that will be needed. Clearly, the activities conducted in FY04 and later years are necessarily contingent on the results of previous years' field and modeling activities. As described in Section 11, a meeting of all parties involved in the hydrology program will be held annually to evaluate progress to date and develop final plans for the coming year.

5.1 New and Replacement Wells

Twelve locations have been identified where data from new wells are needed. These locations are designated with "SNL-#" labels in this document. Some of these wells are expected to provide information directly relevant to the scenarios under consideration, while others will provide information needed to support our conceptual and numerical models. In addition, a long-term Culebra monitoring network consisting of fiberglass-cased wells at potentially 21 locations has been designed to provide the data needed for compliance with the requirements of the WIPP HWFP. These wells will replace the existing network of steel-cased wells that are deteriorating and in need of plugging and abandonment. The 21 locations for the long-term monitoring network are designated with "WTS-#" labels. Well locations have been optimized so that five wells can serve as both SNL and WTS wells, reducing the total to 28 locations. Preliminary locations for the wells are shown in Figure 8. However, the final number and locations of the WTS wells will be optimized based on the modeling described in Section 4. Seven other existing well locations outside the extent of the HWFP network have been identified that will likely require replacement wells in the future to continue to provide data needed for Culebra modeling. New Magenta wells will be installed at six of the SNL- and WTS-designated locations to provide data needed for scenario evaluation and modeling. Five Dewey Lake wells are planned for locations north of the WIPP site where Dewey Lake water is encountered while drilling the Culebra wells. The justifications for the 12 SNL locations are given below, followed by the justifications for the WTS locations and the "far-field" replacement locations. Table 1 shows the roles to be played by each of the wells. The sequencing of drilling and testing in the new wells is described and explained in Section 6.

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Table 1. Roles Served by Planned Wells.

Well	Addresses leakage from tailings pile	Addresses high-T conduits	Addresses leaking boreholes	Addresses Salado dissolution	Provides model boundary condition information	Provides other information needed for modeling	Provides information supporting conceptual model	Provides information on flow across WIPP site
SNL-6					X		X	

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SNL-6: A Culebra well will be installed at this location near the northeastern boundary of the Culebra flow model (see Figure 8). This location is critical in establishing accurate model boundary conditions that will allow us to assess the effects of potential vertical-leakage pathways to the Culebra (either the Mississippi East tailings pile or leaky boreholes). Without accurate boundary conditions, we cannot use a model to determine if vertical leakage is, or is not, needed to explain observed water-level rises. The primary purposes to be served by SNL-6 are:

1. provide needed boundary conditions (both head and transmissivity) for the northeastern area of the Culebra flow model; and
2. confirm the hypothesis in our conceptual hydrogeologic model that Culebra transmissivity is low in this region between the m2/h2 and m3/h3 halite margins

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Table 2. Testing to Be Performed in New/Replacement Wells.

Well	4-day Pumping Test	Slug Tests	Multipad Pumping Test	Scanning Colloidal Borescope Logging	Testing Not Needed—Replacement Well
SNL-6		C			

C=Culebra well
M=Magenta well
DL=Dewey Lake well

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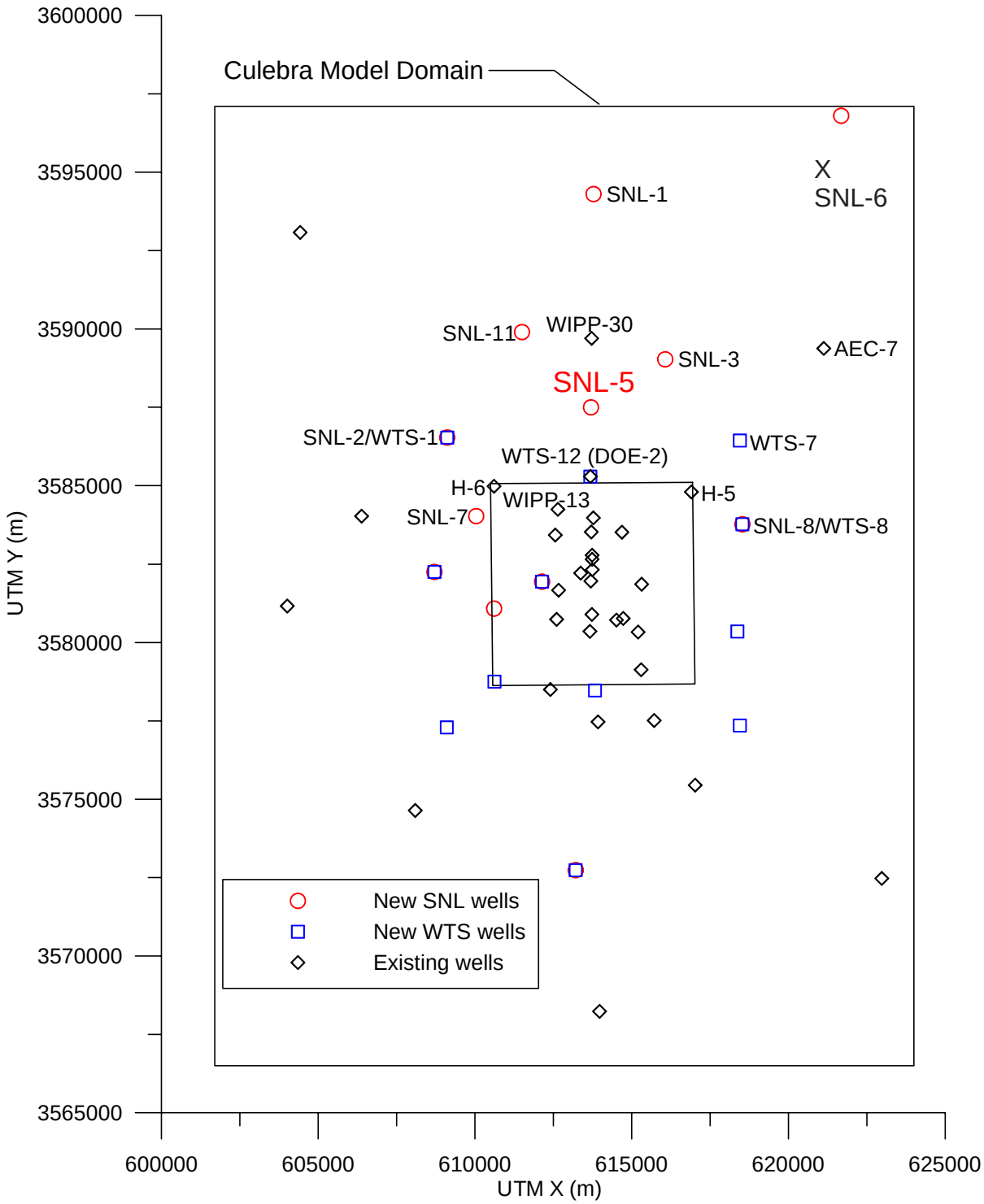

Figure 19. Pumping well and principal observation wells for northern multipad pumping test.

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6.3 Decision Points

As discussed above, the drilling, testing, and P&A sequences just described assume that all new wells meet our expectations, no existing wells fail and need immediate plugging and abandonment, etc. In the event that unexpected or unforeseen conditions arise, the schedule and sequence of activities will be modified as appropriate. A number of decision points can be foreseen, depending on the conditions actually encountered.

Wells SNL 1, 3, 9, and 12 have been located with clear expectations that they will encounter conditions and properties that help explain the changes in Rustler water levels. SNL 1 is expected to show high Magenta and Culebra heads, possibly equal, as a result of leakage from the Mississippi East tailings pile. SNL 3 and SNL 9 are expected to show high Culebra T resulting from dissolution of the upper Salado. SNL 12 is expected to show the high Culebra T predicted by all Culebra flow models since the late 1980's. In contrast, SNL 6 and SNL 8 are expected to show low Culebra T. If the expected conditions and properties are not found at these locations, our conceptualization of the system, and our strategy for characterizing it, may have to change.

…

Because of the depth to Culebra at SNL 6 and SNL 8, transmissivities are expected to be low at those locations. However, those locations are also near to and on the western side of the m3/h3 halite margin, where dissolution is possible and high T has been found in other wells (e.g., H 11). If high T were to be found at SNL 6 and/or SNL 8, we would have to re-evaluate our conceptual understanding of flow east of WIPP. We would also need to perform a long enough pumping test to determine if high-T connections existed to nearby wells.

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Table 4. Expectations and Contingent Actions for New Wells.

Well	Expectations	Possible Actions if Expectations Not Met
SNL-6	• low Culebra T	• establish connectivity with SNL-1 and SNL-3 • consider additional well to the southwest between the m2/h2 and m3/h3 halite margins

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Table 5. Anticipated Total Depths of Proposed Wells.

Location	Culebra Well Depth (ft)	Magenta Well Depth (ft)	Dewey Lake Well Depth (ft)
SNL-6	1505		

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Consulting Geologist

August 1, 2004

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Hydrology Lead
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Ronald G. Richardson
Field Lead
Washington Regulatory and Environmental Services
P.O. 2078
Carlsbad, NM 88220

Dear Rick and Ron:

By request from Rick Beauheim, I have re-examined geologic data in the vicinity of the following potential locations for drillholes to provide recommendations on whether the locations are appropriate, considering the objectives of the drillholes.

Drillhole Name	General Location	Hydrologic Objectives	Geologic Information
SNL-6	500’ fnl & fel, 7-21-32	Model boundary conditions; conceptual model: low T in area with H-2 and M-3	Better logs show H-3 present; move south ~ 1 mi
SNL-8	@ P-20; 800’ fsl, 100’ fel, 14-22-31	Confirm assumed low T east of WIPP, located in area of possible dissolution of halite from H-3; provide info on Culebra heads in area with many O&G wells	Logs re-examined confirm M-3 and indicate possible thicker M-3 adjacent to inferred halite margin at P-20 and adjacent O&G wells
SNL-13	SE ¼, 1-23-30	Replace WTS-4, provide monitor well in area off SW corner of WIPP where some models show flow is forced	No halite in H-2, -3, or -4; probable H-1 halite cements in most drillholes
SNL-14	SE ¼, 4-23-31	Examine area between P-17 and H-17 for possible high T zone indicated in CCA	No drillhole or other data helps define the mudstone-halite boundaries in M-2/H-2, M-3/H-3, and M-4/H-4
SNL-15	@P-10; 2300 fnl, 340’ fwl, 26-22-31	Confirm T values in area with halite in all Rustler units along eastern boundary of WIPP	Drillhole data confirm halite present in P-10 and nearby oil and gas drillholes

Locations for SNL-6 and SNL-14 provide some challenges. From preliminary analysis, additional logs near the northeast corner of the hydrology domain indicate that halite is present farther west than was indicated in the original analysis (Powers, 2002). Although it is desirable to locate SNL-6 in an area without H-3, determining Culebra hydraulic properties near the boundary of the hydrologic domain is more important. SNL-6 would have to be located at considerable distance from this corner of the domain to assure not encountering H-3. Because SNL-14 is intended to test for the presence of a high T zone in the Culebra between H-17 and

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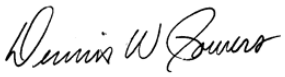
P-17, the drillhole should be located where H-3 is not present to minimize effects it may have on Culebra T values. Nevertheless, there are no drillholes between H-17 and P-17 to help delineate this margin. SNL-14 was therefore located approximately midway between the drillholes.

The coordinates for the drilling pads for each hole are:

Drillhole Name	UTM X (m) (NAD27)	UTM Y (m) (NAD27)	T,R Approximate Location (estimated)
SNL-6	621294	3595390	7-21-32, 1825 fsl, 1250 fel
SNL-8	618522	3583793	14-22-31, 900 fsl, 125 fel
SNL-13	610406	3577599	1-23-30, 1750 fsl, 400 fel
SNL-14	614871	3577302	4-23-31, 800 fsl, 1475 fel
SNL-15	617137	3581276	26-22-31, 2100 fnl, 500 fwl

Map locations, aerial photos with locations, and some site figures for each drill hole are included in the following pages.

Sincerely,

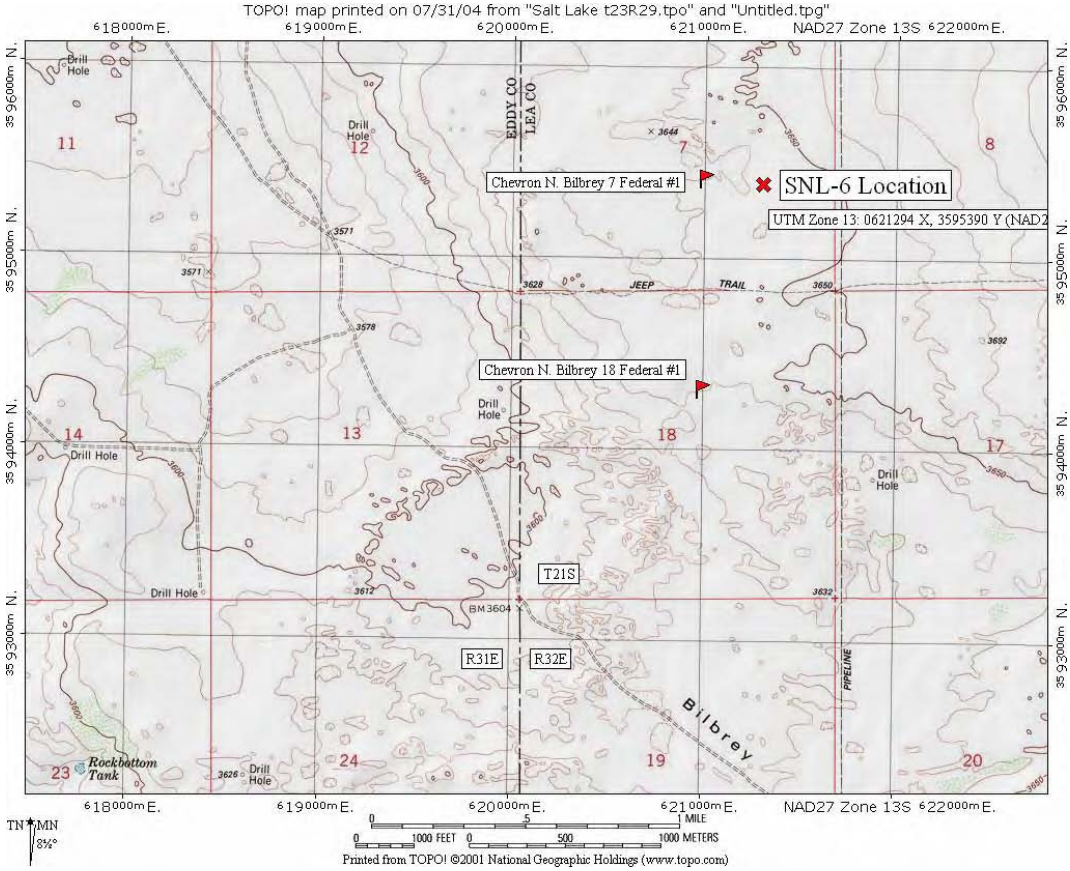


Dennis W. Powers

NOTE: Some pages of this memorandum are omitted because they are not relevant to SNL-6.

Dennis W. Powers, Ph. D.
Consulting Geologist

Assessing FY05 Drillhole Locations
August 1, 2004



SNL-6 Location map and location photos.

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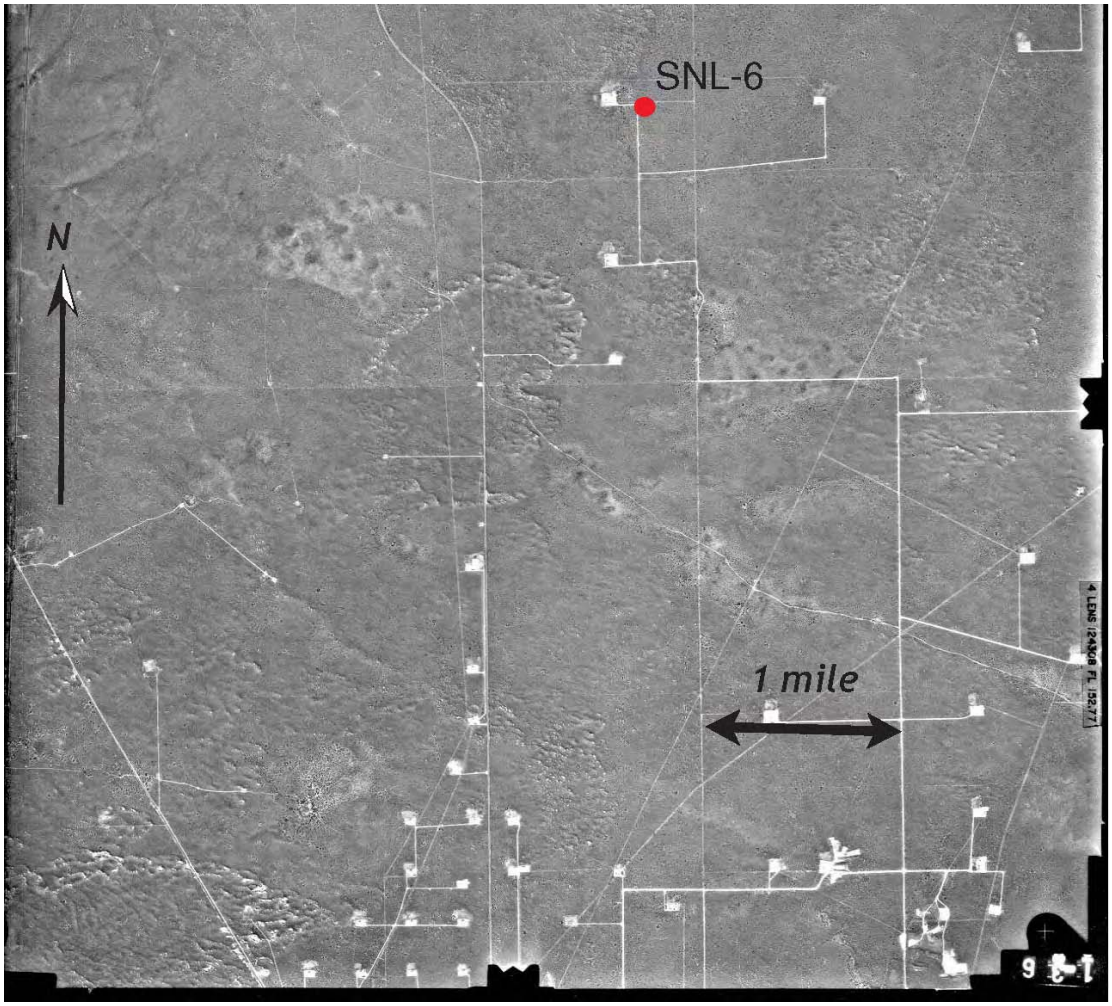

Aerial photograph (NAPP 9610-136, dated10-22-96) with location of SNL-6.

Dennis W. Powers, Ph. D.
Consulting Geologist

March 6, 2005

Ron Richardson
Field Lead
WRES

Rick Beauheim
Hydrology Lead
Sandia National Laboratories

Drilling Estimates and Revisions for New Hydrology Wells FY2005

Because of limits to the budget for drilling in 2005, I have revised the expectations for drillholes SNL-6, SNL-8, SNL-13, SNL-14, and SNL-15 (see accompanying Excel workbook). Here I also describe the differences with respect to the hydrology plan and also initial points about these drillholes (notes adjacent to initial Excel worksheet). In reassigning coring intervals and drilling depths, I have made an attempt to maximize the information for higher priority items. That does not mean that I think the earlier objectives were unnecessary or inappropriate. At the end of the summary, I provide some additional priorities for decision-making based on incremental costs as they accrue. For easy reference, a generalized diagram of the stratigraphy of each hole and the the intervals to be cored under this revision is included at the end of the drillhole summaries.

SNL-6

Prior Expectations for SNL-6

SNL-6 was originally located in the area of the northeast corner of the hydrological modeling domain. Its purpose is to establish model boundary conditions that are important in evaluating potential vertical-leakage pathways to the Culebra. In addition, the transmissivity of the Culebra at SNL-6 was expected to be low because it is generally in the vicinity of halite in Rustler units M-2/H-2 and M-3/H-3. SNL-6 was originally scheduled to be drilled during FY04.

The hydrology plan generically indicated that wells such as SNL-6 would be cored through the Magenta Dolomite Member (~30 ft) and from the lower part of the upper Tamarisk Member anhydrite to about 20 ft below the Culebra Dolomite (~70 ft) for a total of about 100 ft.

My initial forecast called for coring from the uppermost anhydrite of the Forty-niner Member through the base of the Rustler and into the upper Salado, a total of about 350 ft. This more ambitious plan was based on the lack of control for the mudstone/halite facies in all units and unknown effects on the hydrology of the Culebra and other units. It is not believed that the upper Salado is being dissolved at this location and drilling was projected for about 50 ft below an expected top of Salado. Coring above and beyond the hydrology plan included the Forty-niner mudstone and basal anhydrite, all of the upper Tamarisk anhydrite, and all of the Los Medaños plus a short interval in the upper Salado.

Current Plan for SNL-6

The current location for SNL-6 is south of the original location, but it is in the same geological setting. Halite is anticipated in M-2/H-2, although data are sparse. The current location is not within the boundary for halite in either M-3/H-3 or M-4/H-4, but the boundary for M-3/H-3 is also not well constrained in this area.

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Drilling Estimates and Revisions FY2005
March 6, 2005

The revised drilling estimate is only to the depth below the Culebra necessary to establish the casing and screen interval through the Culebra. The revised core intervals include the Forty-niner mudstone and Magenta to examine the M-4/H-4 halite margin. The Tamarisk mudstone (M-3/H-3) above the Culebra is partially cored under this plan. It is expected that halite is present in this unit.

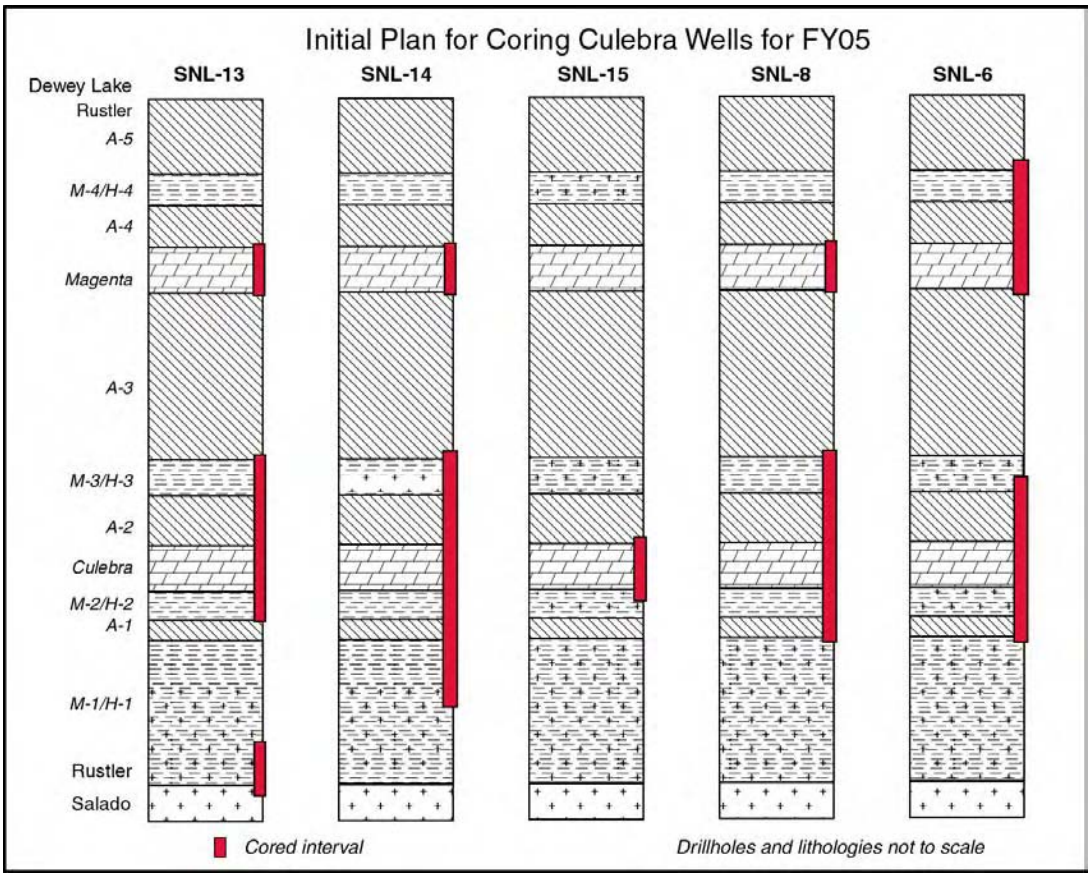
The revised plan will eliminate coring and drilling of intervals through the lower Rustler and into the upper Salado. There will be no extension of detailed facies relationships or estimation of dissolution effects, if any, from these zones.

NOTE: Portions of this memorandum not relevant to SNL-6 have been omitted.

Dennis W. Powers, Ph. D.
Consulting Geologist

Drilling Estimates and Revisions FY2005
March 6, 2005

NOTE: Portions of this memorandum not relevant to SNL-6 have been omitted.



Priorities for Making Decisions During Drilling

Expansion of Drilling and Coring
If the accrued expenses of drilling permits additional targets to be designated, here are my priorities, from higher to lower:

- M-4/H-4 at SNL-8 (+ 35 ft)
- Magenta Dolomite at SNL-15 (+ 30 ft)
- Extend coring above and below Culebra (+ 40 ft)

Contraction of Drilling and Coring
If accrued expenses of drilling require coring to be reduced in later drillholes, here are my priorities, from first to be reduced to last to be reduced:

- Eliminate Magenta at SNL-8 (- 30 ft)
- Eliminate Forty-niner coring at SNL-6 (- 40 ft)
- Eliminate Magenta coring at SNL-6 (- 30 ft)

Dennis W. Powers, Ph. D.
Consulting Geologist

Drilling Estimates and Revisions FY2005
March 6, 2005

Summary Comments on Revisions

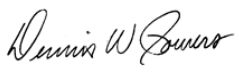
The initial program of drilling and coring I recommended was aggressive, and I intended it to provide a solid base of physical evidence bearing on the geohydrological factors that contribute to the understanding of the spatial variation in the hydraulic properties of the Culebra Dolomite as well as the Magenta Dolomite. A hydrogeological conceptual model of the Culebra has been put forward, and these drillholes provide additional means of testing that model. Although a similar conceptual model of the Magenta has not yet been established, the spacing and distribution of these drillholes potentially add much to the existing coverage, as the eastern sector of the WIPP hydrologic modeling domain is not well represented by cores. Although Salado dissolution is not expected to be a significant factor in any of these five locations except possibly SNL-13, the distribution of halite and other Rustler facies, along with depth, are expected to be significant for the Culebra. The general distribution of halite in the Rustler is believed to be well known, but the margins are still poorly sampled to determine the potential for dissolution to have affected local halite distribution and hydraulic properties of these units.

With budget limitations in mind, I have attempted my version of *triage* – to sort or allocate on the basis of need for or likely benefit from ….

I have eliminated all drilling and coring of the basal Rustler and upper Salado except for SNL-13, which is located in part to test the potential effects of upper Salado dissolution. Data from other drillholes will supplement the estimate of upper Salado dissolution at SNL-13 and the amount of coring and depth has been greatly reduced. Drilling of the basal Rustler and upper Salado in the remaining holes, without core, would not significantly improve knowledge, although a specific data point on the contact might be provided by a geophysical log. I have eliminated coring of any units significantly above or below the Culebra in SNL-15 because there is little doubt about the presence of halite in all mudstone/halite units. I have also eliminated coring of some mudstone/halite units in different holes to focus on the greatest priority, the Culebra Dolomite.

Thirty years of experience at WIPP indicate to me that the cost of not having information and the cost of later providing equivalent information is more expensive than the savings of the moment. Nevertheless, I provide here a basis for choosing drillhole depths and core intervals from the five wells to be drilled and completed in FY04 with these limitations in mind. I will work with you on priorities as the drilling unfolds to do my best to balance the technical needs and budgetary limitations.

Sincerely,



Dennis W. Powers

Appendix B
Abridged Borehole History

The abridged borehole history has been prepared by compiling information from driller's reports by West Texas Water Well Service (WTWWS) personnel, on-site reporting by Washington Regulatory and Environmental Services (WRES) personnel, and geologic logs by Dennis W. Powers. The main information is from WTWWS reports, which are reported as Central Daylight Time. For consistency, all information in the abridged borehole history has been converted to Central Daylight Time, regardless of source. Original files are maintained by WRES in the Environmental Monitoring and Hydrology Section.

Note: The abridged drillhole history provided here has been compiled mainly from the daily records produced by personnel of West Texas Water Well Service (WTWWS) and provided to Ron Richardson (Washington Regulatory and Environmental Services). The information has been reformatted and has been modestly edited. *Additions to the record from notes by Dennis Powers or other personnel are in italics.* All times reported in the abridged drillhole history are in CDT (Central Daylight Time) as recorded by WTWWS because they operate from Odessa, TX. Any additional notes included here (*in italics*) with times recorded in MDT (Mountain Daylight Time) at the site have been converted to CDT. Geologic logs (main body of text) have times as MDT, and times in the geologic logs commonly vary slightly from the driller's log after allowing for the hour time difference.

The first part of the drillhole history describes the drilling and eventual plugging and abandoning of SNL-6A. The later drillhole history describes the drilling and completion of SNL-6, which is completed in the Culebra and monitored.

7-5-05 Moved rig at 09:00 and put plastic down at SNL-6A. Dig down 5' and set temporary 20" casing; cement in place by 12:30. Action Safety on site 11:00 to 11:30. Broke bit off reamers, and set up air compressers and rolloff. Departed at 17:30.

7-6-05 Arrived on site at 07:10 and held safety meeting. Put bit on by 08:08. Began drilling from 5'; reached 69' at 10:15. Put diverter on. Went to SNL-8 for diesel tank, and lined rolloff by 14:12. Drilled from 69', reaching 247' at 18:55. Tripped off bottom by 19:05 and departed site.

7-7-05 Arrived on site at 08:10. Held safety meeting. Completed tripping out by 09:15 and removed diverter at 09:40. Checked for water in hole and found it dry. Broke bit off reamers. Constructors was on site at 10:30 and completed pit by 11:50. Drilled 17.5" hole from 5' to 60', finishing at 13:45. Ran 63' of 12.75" casing into hole by 14:50, leaving 3' above ground level. Put 3 bags of HolePlug® in bottom of hole; waited on cement. *Cement truck on site at 15:25.* Cemented casing to surface with 2 cubic yards by 16:00. Departed site.

7-8-05 Arrived on site at 07:15. Held safety meeting. Cut surface casing off at pad level and moved rig back over hole. Found crack in 6.625" bit sub; left for Odessa at 08:20 for repairs and weekend break.

7-11-05 *Ran Solinst in hole at 07:45 and did not detect water.* WTWWS crew arrived on site at 08:40. Held safety meeting. Put new 11" bit on and tripped into drillhole. Installed diverter by 09:40. Cleaned out fill to 247' by 10:30. Began drilling new 11" hole from 247' at 10:38. Changed rolloff with cuttings from 14:08 to 14:58. Began drilling with mist at 416'. Reached 496' at 18:12.

7-12-05 Arrived on site at 07:30. Held safety meeting. Tripped into hole and measured fluid level at 08:50 in hole at 380.36' below rotary table (5.25' above concrete pad). Went for truck load (90 barrels) of water. Blew water from hole while tripping in and reached bottom at 10:50. Began drilling from 496' and reached 712' at 17:00. Used 8 gallons of soap *(EZMud®)*. Blew water from hole until 17:10. Tripped out and removed to drill collars. Departed site.

7-13-05 Arrived on site at 07:40. Held safety meeting. Began tripping into hole at 07:50 to ~615'. Measured apparent water level inside drillpipe with Solinst at 501.5' below rotary table (5.25' above cement pad) at 09:10. Blew water from hole while tripping to bottom at 11:07. Began drilling 11" hole from 712' at 11:07. *Tripod on site to change out rolloff. Grab sample of water from overflow of diverter while blowing down hole was allowed to stand until sediment was mostly settled. A field measurement with an uncalibrated hydrometer showed specific gravity less than 1.005. Sample may include soap (EZMud®), water added during misting, and some sediment.* Ended drilling at 875' at 18:03. Used 12 gallons of soap during day. Cleaned hole out and tripped out to collars. Departed site at 18:50.

7-14-05 WTWWS arrived on site at 08:10 and held safety meeting. Serviced rig. Tripped into hole with drill pipe and measured water level at 702.2' (reference point 5.25' above cement pad). Began drilling 11" hole from 875' at 09:57. Began using additional EZMud® at 950', resulting in larger cuttings returned to surface. Ended drilling at 1,070' at 15:49 to prepare for coring. Used total of 15 gallons of EZMud®. *Installed pressure probe in well at 18:00 and departed site at 18:15.*

7-15-05 WTWWS arrived on site at 08:00 and held safety meeting. Pulled pressure probe from well by 08:25. [Note: data not recovered from instrument.] Installed diverter and put core tool together. Tripped into the hole by 11:55. Began coring from 1,070' and cored to 1,098' by 12:45 and cleaned hole out. Tripped out of hole by 14:14 and laid down core. Recovered 22.3' of core. Ran core tool plus 1 collar into hole by 14:50, and shut down operations. Used 5 gallons of EZMud®.

7-18-05 WTTWWS arrived on site at 08:40; held safety meeting. Tripped 1 joint of drill pipe into the hole. Measured water level at 399.8'. Tripped in while unloading hole. Began coring from 1,098' at 12:50 and reached 1,128' at 13:17. Circulated hole to 13:35. Tripped out by 14:44. Laid down core; recovered 30'. Laid core tool down by 15:15. Removed diverter. Put 11" drill bit on. Installed diverter and tripped into hole by 15:15. Drilled out 11" hole from 1,070' to 1,112' by 18:30. Used 10 gallons of soap. Rotary table broke. Circulated hole to 18:40 and tripped out by 19:35.

7-19-05 WTTWWS arrived on site at 12:45. Held safety meeting. Installed rotary table on rig by 13:30. Tripped into hole by 15:25 while unloading hole. Found 24' of fill and made decision to begin drilling with brine. Used 5 gallons of soap. Tripped out of hole by 16:20. Removed diverter, watered road, moved air compressor. Departed 18:00.

7-21-05 Arrived on site at 07:30. Held safety meeting. Rigged up water line and worked on pit desander. Tripped into hole starting at 10:40 while mixing EZMud® and circulating. Drilled 1,112' to 1,126' from 14:50 to 17:00. Hole will not clean out. Tripped out of hole by 17:45. Used 45 gallons of soap. Departed site.

7-22-05 Arrived on site at 08:10. Held safety meeting. Started up pit system. Tripped to 300', circulating clear brine by 09:20. Tripped into hole by 13:00, washing to bottom and making brine mud with Zeogel®. Began reaming at 1,126', reached 1,128' at 13:50. Drilled to 1,143' at 17:40. Circulated on bottom. Used one pallet of Zeogel®. Tripped out of hole completely by 18:40 to look at 11" bit. Departed site.

7-23-05 Arrived on site at 07:20. Held safety meeting. Mixed mud until 08:20. Tripped into hole by 10:20. Mixed mud (Zeogel®) and drilled by 25' of fill to 1143' by 10:55. Started drilling at 1,143' from 10:55 and stopped drilling at 1,170' at 17:40. *Removed 380 barrels of water from SNL-6 frac tank to SNL-8 tank.* Circulated on bottom and tripped out of hole by 18:40. Used one pallet of Zeogel®. Departed site.

7-24-05 Arrived on site at 07:25 and held safety meeting. Tripped into hole by 08:15. Lost drilling mud in hole at 300'. Shut down operations until more mud can be brought from Odessa on 7/26/05. Pipe laid down, secured site, departed at 08:30.

7-26-05 Arrived on site at 07:10 and held safety meeting. Will begin 24-hour schedule due to hole instability. Tripped in, reaming each joint down. Began drilling 11" hole from 1,170' at 11:40. Reached 1,260' at 19:14. Used 1.5 pallets of bentonite. Night crew arrived and held safety meeting. Changeover to night crew. Stopped drilling at 22:15 to adjust rotary table clutch; resumed drilling at 22:30. Light rain falling starting 22:54.

7-27-05 Continued drilling on 24-hour schedule. Reached coring point at 1,292' at 00:10. Circulated on bottom until 00:20 and began to trip out of hole. Repaired mud pump hose from 01:15 until 04:30; shut down rig until 06:00 due to heavy rain. Completed tripping out at 07:00. Day crew arrived and held safety meeting. Changeover crew. Began tripping core tool in hole at 07:10. Began coring from 1,292' at 09:20 and reached 1,322' at 12:20. Circulated on bottom until 12:50. Tripped out and laid down core by 14:20; recovered 30'. Tripped core barrel back to bottom by 16:30 and began to core from 1,322'. Reached 1,327' at 17:47 and tripped out because core jammed up barrel. Completed tripping out by 19:10. Laid down core; recovered 4.3'. Night crew arrived and held safety meeting. Changeover to night crew. Tripped core barrel into hole by 22:30 and began to core from 1,327'.

7-28-05 Continued drilling on 24-hour schedule. Reached 1,357' at 02:00 and circulated on bottom until 02:30. Tripped out of hole with core barrel by 04:15 and laid down core at 04:50; recovered 29.5'. Began dismantling core barrel for loading and preparing to ream cored interval to 11" diameter. R. Keith called and requested logging hole before reaming; pulled reamers and bit from hole. DOWDCO crew departed site at 06:25. Day crew arrived on site and held safety meeting. Changeover to day crew. Al Henderson (JetWest) arrived on site at 08:00 to log drillhole. Rigged up and completed logging of hole by 12:00. Tripped into hole to ream cored interval and began reaming at 15:38. Night crew arrived on site at 18:30; crew changeover at 19:00. Continued to ream cored interval.

7-29-05 Continued drilling on 24-hour schedule. Day crew arrived at 06:55 and held safety meeting. Changeover to day crew at 07:10, continued to ream cored interval to 11" diameter. Reached 1,360' at 09:45 and circulated on bottom until 10:45. Tripped out of hole by 12:00. Moved drillpipe off rack by 12:30. Ran tremmie pipe into hole by 13:44 and broke for lunch. Unloaded casing and tallied lengths by 15:00. Began running casing into hole at 15:00 and finished at 18:15. Night crew on site and held safety briefing. Changeover to night crew. Began to run gravel. Tremmie line stuck in hole at 19:30. Crew worked to free tremmie without success until 22:30. Began to pull casing from hole at 22:45.

7-30-05 Continued drilling on 24-hour schedule. Completed pulling casing from hole at 02:00. Tried unsuccessfully to pull tremmie pipe from hole. Night crew shut down rig and departed site.

8-1-05 WTWWS crew arrived on site at 12:30 and held safety meeting. Took casing off rack and loaded on trailer by 13:30. Pumped mud from earth pit to steel pit by 14:00. Loaded drill pipe on rack by 15:00. Tripped into hole by 16:10 with drill pipe to try to wash over tremmie line. Tripped out with drill pipe by 17:00. Ran fishing tool to grab tremmie by 17:50. Pulled 400' (of 1,330') of tremmie by 18:30. Shut down and departed site.

8-2-05 Arrived on site at 07:45. WTWWS arrived and prepared to cement well through tremmie remaining in hole. Southeast Ready Mix arrived on site at 10:45 with first load of cement, and second truck arrived at 10:56. Cement too dry to pump down hole; sent trucks back to yard to remix at 11:40. Mike Stapleton (Office of State Engineer) arrived on site at 11:50. Southeast Ready Mix trucks arrived on site at 15:00 and pumped load downhole. Pulled 10 joints of tremmie. Second truck arrived and finished pumping load downhole at 16:00. Pulled 10 joints of tremmie. Third truck arrived and pumped load downhole by 16:35. WTWWS finished pulling tremmie pipe from hole and laid down by 17:15. Used total of 650 sacks of cement from 1,030' to surface.

The following activities are for SNL-6, drilled along the eastern side of the drillpad.

8-23-05 WTWWS arrived on site at 08:30 and held safety meeting. Rigged up air compressor and roll off by 15:00. Drilled 4' of 17.5" hole and set 4' of 14.75" surface casing in place by 16:00. Rigged up 12.25" bit. Departed site at 16:30.

8-24-05 WTWWS arrived on site at 08:00 and held safety meeting. Rigged up air hose for drilling by 08:48. Drilled 12.25" hole from 4' to 15' by 10:20. Added reamers and worked on air compressor. Drilled 12.25" hole from 15' to 48' by 11:55. Installed diverter. Mike Stapleton (Office of State Engineer) on site 12:35-12:47 to inspect surface casing. Began drilling 12.25" hole from 48' at 14:40 and reached 132' at 17:17. Cleaned hole out and pulled 60' of drill pipe by 17:25. Departed site.

8-25-05 WTWWS arrived on site at 07:20 and held safety meeting. Tripped into hole by 07:55 and began drilling 12.25" hole from 132'. Reached 195' at 10:25. Hole would not clear

out cuttings; began to use mist. Rigged up pump on roll off and covered roll off by 11:30. Began drilling from 195' and reached 320' at 17:02. Used 6 gallons of soap. Cleaned hole out and tripped out to reamers by 17:24. Departed site.

8-26-05 WTWWS arrived on site at 07:30 and held safety meeting. Serviced rig by 08:20 and began tripping into hole. On standby until 11:15 for roll off. Began drilling 12.25" hole from 320' at 11:15 and reached 472' at 18:33. Used 10 gallons of soap. Cleaned hole out and tripped out to reamers. Went for load of water and left site at 20:15.

8-27-05 WTWWS arrived on site at 07:30 and held safety meeting. Serviced rig. Tripped into hole while blowing water and began drilling 12.25" hole from 472' at 09:08. Reached casing depth of 594' at 17:22. Cleaned hole and tripped out by 18:15. Departed site.

8-29-05 WTWWS arrived on site at 07:15 and held safety meeting. Tripped into the hole, unloading fluid. Reached 594' at 08:45 and circulated on bottom until 09:00. Tripped out of hole by 10:00 and removed diverter. Ran tremmie line into hole by 11:40. Ran casing (8.625") in hole by 13:32. Mike Stapleton (Office of State Engineer) arrived on site at 14:15. Rigged up for cement by 14:40. On standby waiting for cement. Southeast Ready Mix arrived on site with 2 trucks and began pumping cement at 16:45. Elevator broke trying to pull tremmie pipe. Backed off and left 12 joints of tremmie. Pumped total of 162 bags of cement.

8-30-05 WTWWS arrived on site at 07:10 and held safety meeting. Tagged top of cement at ~160'. Waited on cement. Called Office of State Engineer; Mike Stapleton said to pour cement to surface because annulus was dry. Poured cement from 09:35 to 10:00. Loaded up drill pipe on racks by 12:30 and departed.

8-31-05 WTWWS arrived on site at 07:05 and held safety meeting. Cut casing off, installed diverter, tallied drill pipe by 08:40. Tripped into hole, unloading fluid. Began drilling 7.785" hole from 594' at 10:08. Reached 656' at 13:25. Worked on cable for blocks. Stopped drilling from 14:40 to 15:30 because of dust blowing into rig engine. Drilled from 656' to 686' by 17:08. Shut down because of blowing dust. Tripped 3 joints out. Shut down.

9-1-05 WTWWS arrived on site at 07:15 and held safety meeting. Serviced rig and tripped into hole by 07:55. Drilled 7.875" hole to 900' by 18:45 and blew on bottom for 5 minutes. Tripped 300' of drill pipe out and shut down by 19:15.

9-2-05 WTWWS arrived on site at 07:15 and held safety meeting. Tripped into hole and began drilling 7.875" hole from 900' at 07:50. Reached 1,028' at 11:25. Cleaned out hole and tripped out 400' of drill pipe by 12:10. Shut down and departed site.

9-6-05 WTWWS held safety meeting in Odessa yard; arrived on site at 10:38. Serviced rig and changed cable on blocks by 13:00. Tripped into hole by 14:00. Fixed diverter hole. Began drilling 7.875" hole from 1,028' at 14:50. Reached 1,095' at 17:35. Damp from 1,070-1,080'. Tripped out 300' and shut down. Will switch to brine mist drilling.

9-7-05 WTWWS arrived on site at 07:15 and held safety meeting. I.W. onsite with 90 barrels of brine. Tripped into hole and started blowing water from hole ~50' above total depth. *Specific gravity ~1.203.* Began drilling 7.875" hole from 1,095' at 08:24 using brine mist. Reached 1,360' at 17:00. Cleaned hole out and tripped 450' of drillpipe out of hole by 17:35. Used 20 gallons of soap and 90 barrels of brine.

9-8-05 WTWWS arrived on site at 07:20 and held safety meeting. Tripped into hole by 08:50 and cleaned out 40' of fill. Circulated on bottom until 09:03. Tripped out by 10:35. Took drill pipe off rack and tallied tremmie pipe by 11:30. Ran tremmie pipe into hole by 13:50. Ran casing into hole until stopped at 1,065'. Pulled tremmie pipe out by 18:20. Pulled casing up into surface pipe by 19:30 and departed site.

9-9-05 WTWWS arrived on site at 08:35 and held safety meeting. Pulled rest of casing by 10:45. Loaded drill pipe onto rack by 11:20. Installed diverter. Ran 600' of drill pipe into hole by 13:30.

9-10-05 WTWWS arrived on site at 07:05 and held safety meeting. Waited for daylight until 07:25 to begin. Tripped into hole and cleaned out 18' of fill by 10:15. Circulated on bottom of hole until 10:40. Tripped out by 11:30. Removed diverter and took drill pipe off of rack by 11:45. Installed tremmie by 13:00. Ran 2.5" fiberglass-reinforced plastic casing into hole by 15:40. Moved pipe racks and cut off casing by 16:30. Pumped gravel from 1,350' to 1,305' by 16:45 and tagged top of gravel. Placed 3 bags of HolePlug® to bring up to 1,300'. On standby for cement until 19:30. Pumped first load of cement by 20:10 and second load by 21:05. Pulled tremmie pipe by 21:40. Used 15 gallons of soap during cleanout. Used 486 sacks of cement.

9-13-05 WTWWS arrived on site at 07:10 and held safety meeting. Waited until sufficient daylight at 07:30. Tagged cement in annulus at ~90' below ground surface. Rigged up to blow water from well. Well was dry to 600'. Used 350 psi with no return at 1000'. Pulled 200' and blew soap from hole for two minutes at 330 psi. Discharge line broke and was replaced. Blew head off at 800' by 16:45. Blew well again at 900' at 350 psi. Added pipe to 1,306' and finished blowing well dry at 19:20. Departed site. [Daily logs do not record activity to cement the annulus above ~90'. R. Salness, WRES, inspected the wellhead 01-04-10 and found that the cement in the annulus at SNL-6 is ~38" below ground surface (personal communication to Dennis Powers, 01-05-10).]

9-14-05 WTWWS arrived on site at 07:30 and held safety meeting. Started compressor and blew well at 1,306' without returning any fluid. Cleaned up site, moved trailer and compressors. Tripped air line out of hole by 12:45. Loaded trucks and cleared site.

Dragonfly on truck radio antenna at SNL-6. Photograph by Dennis W. Powers, July 11, 2005.

Appendix C
Geologic Logs

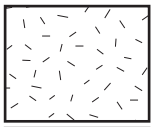
Note: The original field descriptions and graphic logs were prepared at differing scales, and the graphic logs for publication were generally produced at 10 or 20 vertical ft per inch, as indicated in the header for the log.

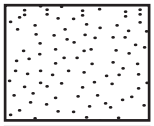
The field descriptions were related to depth based on drilling information and core recovery as best determined in the field. Core and sample footages are marked accordingly and can vary somewhat from depths determined for stratigraphic units based on geophysical logs (see Table 2-1 of text). Core depth markings have not been revised to reflect later geophysical log data. Depths used for completing the well are based on geophysical logs.

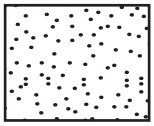
The geologic logs presented here are for SNL-6A, the original borehole at this location. It was plugged and abandoned (see Chapter 1), and SNL-6 was drilled and completed on the same pad based on the geology of SNL-6A.

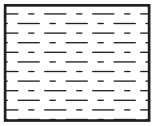
Explanation of Symbols Used in Lithologic Logs (Appendix C)

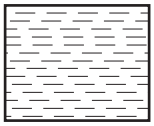
Lithology

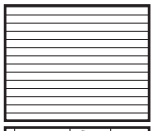

Construction fill

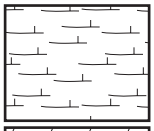

Fine sand or sandstone

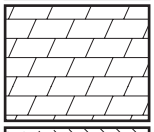

Medium or coarse sand or sandstone

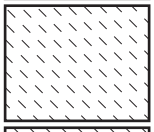

Siltstone

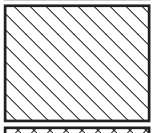

Claystone

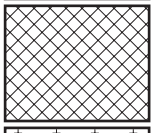

Organic-rich, claystone

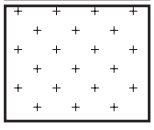

Carbonate (pedogenic calcrete)


Dolomite


Gypsum


Anhydrite


Polyhalite


Halite

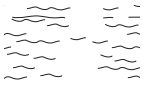
Features


Cross-cutting strata


Ripples


Bioturbation

Stylolite


Wavy bedding


Stromatolites, algal bedding

Vertical gypsum crystals


Gypsum nodules


Clasts, may show lithology as fill pattern


Brecciated, fractures

Fracture, f_g for gypsum-filled, f_h for halite-filled

Erosional boundary

Sharp lithologic contact


Gradational lithologic contacts

hz Hard-drilling zone

sl Slickensides

ns No cuttings sample

Symbols may be combined; not all symbols may be used

CORE LOG — Sheet 1 of 14

Hole ID: SNL-6A

Location: SE 1/4, section 7, T21S, R32E, Eddy Co, NM

Drill Date: 7/06/05

Drill Crew: WTWWS; Luis Armendariz; Ronnie Keith

Drill Method: Rotary, with air

Hole Diameter: 11 inches

Hole Depth:

Hole Orient: vertical down

Drill Make/Model: Gardner-Denver 1500

Barrel Specs: 4" i.d.; 6.75" o.d.

Drill Fluid:

Core Preserv: as recovered, in boxes

Logged by: Dennis W. Powers, Ph.D., consulting geologist

Date:

Scale: variable

	Northing	Easting	Elevation
Survey Coordinate:			

Comments: Pilot 7 7/8" hole to 20' on 7/5/05, caliche <1', maybe mostly pad construction

Run Number	Depth ( )	% Recovered	RQD	Profile (Rock Type)	Description	Remarks
	0				possible caliche at 6', more likely fill from upper part and pad.	drilling with air 5' temporary surface conductor, begin at 5' at 0708 MDT
	10	C-1			5+', Sandstone, damp and malleable (eolian dune?); red (2.5YR5/6 when slightly moist); very calcareous; sand is very fine to medium, subangular to subround; 1-2% opaques; surface shows dark MnO_2 stains	
					15': includes black stain (MnO_2) on surfaces, some argillaceous siltstone (probably Berino soil)	
	20	C-2				
		C-3			24-30': Limestone, sandy, and calcareous sandstone, very pale brown (10YR8/3) to pale brown (10YR6/3) in laminae. Generally well indurated cuttings show laminae indicating stage IV+ pedogenic calcrete (Mescalero caliche). Less calcareous with depth. Sand grains fine to very fine, subround.	
	30	C-4			30': Sand, poorly cemented	
	40	C-5			40': chert, quartz pebbles harder drilling 42'-44' 45' Sand, loose	
					argillaceous from 47'	
		C-6				
	50					

Hole ID: SNL-6A | CORE LOG (cont. sheet) | Sheet 2 of 14

Logged by: Dennis W. Powers, Ph.D. | Date: 7/6/05

Run Number	Depth (ft)	% Recovered	RQD	Profile (Rock Type)	Description	Remarks
	50					
		C-7			57' Base of Gatuña Formation HZ Top of Dockum Group (Tecovas Formation?) 62' damp cuttings, mixed with higher units Sandstone	
	70	C-8			69' Sandstone, argillaceous, to sandy claystone, damp, weak red (7.5R4/2) with thin (~1mm) calcite fracture fillings; and silty claystone; some gray sandstone; very calcareous	
		C-9			HZ 80': Sandstone, fine; with sandy claystone (2.5YR5/2); very calcareous	
	90	C-10			HZ 90': as above, better indurated; more medium sand, very micaceous	
		C-11			100': Sandstone, very calcareous, weak red (10R5/2-4/2); fine to medium, subround to round, grains somewhat coated, 1% opaque grains, mica common on many planes; with some reddish brown (2.5YR4/4) siltstone and white (5Y8/1) fine to very fine sandstone; all very calcareous	
	110	C-12			HZ 110': as above, more siltstone, moderately calcareous	
		C-13			120': as above, increasing siltstone, argillaceous; color more reddish brown; slightly calcareous	
	130	C-14			130': as above, more siltstone and gray (white) sandstone and siltstone; much less sandstone; very calcareous	
		C-15			HZ 140': more reddish-brown siltstone, little sandstone, slightly calcareous.	
	150	C-16			150': as above, slightly calcareous	
		C-17			160': as above, very calcareous	
	170	C-18			170': as above, slightly calcareous	
		C-19			180': as above, slightly calcareous	
	190	C-20			190': as above, slightly calcareous	
		C-21			200': as above, slight increase in sand, very calcareous	
	210	C-22			210': as above, little sand; slightly calcareous	

Hole ID: SNL-6A | CORE LOG (cont. sheet) | Sheet 3 of 14

Logged by: Dennis W. Powers, Ph.D. | Date: 7/6/05, 7/11/05

Run Number	Depth (ft)	% Recovered	RQD	Profile (Rock Type)	Description	Remarks
	210					
		C-23			220': as above, more weak red siltstone, slightly calcareous	215' @ 1709; add jt, begin @ 1716 220' at 1722
	230	C-24			230': as above	225' @ 1729 230' @ 1734
		C-25			240': as above	235' @ 1739 240' @ 1746 245' @ 1752 end drilling 247' @ 1755, 7/6/05
	250	C-26			250': as above, less weak red, more reddish-brown, very calcareous	begin drilling 247' @ 0938, 7/11/05 250' @ 0942
		C-27			260': as above, more weak red, less reddish-brown, slightly calcareous; some gray, very fine sandstone	255' @ 0949 260' @ 0955 265' @ 0959
	270	C-28			270': as above, less weak red, more reddish-brown, very calcareous	270' @ 1003
		C-29			280': as above, more sand, slightly calcareous, very fine to fine, subround, white cement that is non-calcareous	275' @ 1007 277' @ 1009, add jt, begin 1013 280' @ 1021 285' @ 1027
	290	C-30			290': as above, moderately calcareous, very fine to medium (rare) sand Base of Tecovas Formation? Top of Santa Rosa Formation?	290' @ 1033 295 @ 1038
		C-31			300': as above, very calcareous, mostly sandstone, very fine to fine	300' @ 1044 305' @1049
	310	C-32			310': weak red sandstone, very fine to fine, subround; few pebbles	309' @ 1055, add jt, begin 1103 310' @ 1116 315' @ 1121
		C-33			320': Sandstone, with pebbles, mainly of dark gray chert, slightly calcareous	320' @ 1125 325' @ 1130
	330	C-34			330': mainly weak red sandstone, slightly calcareous, some siltstone; sand is very fine	330' @1135 335' @ 1140
		C-35			340': mainly weak red sandstone, slightly calcareous, some siltstone; sand is very fine	340' @ 1146, add jt, break; begin 1225 345' @ 1231
	350	C-36			350': mostly reddish-brown siltstone, as above, very calcareous	350' @ 1244 355' @ 1248
		C-37			360': mostly weak red sandstone with some reddish-brown siltstone, slightly calcareous	360' @ 1255 365' @ 1301
	370	C-38			370': as above	370' @ 1355

Hole ID: SNL-6A | CORE LOG (cont. sheet) | Sheet 4 of 14

Logged by: Dennis W. Powers, Ph.D. | Date: 7/11-12/05

Run Number	Depth (ft)	% Recovered	RQD	Profile (Rock Type)	Description	Remarks
	370					
NA						375' @ 1403
						380' @ 1412
		C-39			380': Sandstone, weak red, slightly calcareous, very fine to fine; some siltstone; very micaceous chips in sample	slight moist feeling to cuttings
						385' @1420
	390	C-40			390': Sandstone, as above, less mica	390' @ 1431
						395' @ 1439
						400' @ 1447
		C-41			400': as above	401' add jt, begin 1454
						405' @ 1500
	410	C-42			410': as above, more micaceous	cuttings starting to cake
						410' @ 1504
						415' @ 1519
		C-43			420': Sandstone, light red (2.5YR6/6); porous, well cemented, not calcareous; generally fine, well sorted, subround, 1-2% black opaque grains	begin mist at 416'
						420' @ 1546
						425' @ 1555
	430	C-44			430': Siltstone, argillaceous, reddish-brown (2.5YR4/4); sandy zones; slightly calcareous	430' @ 1559
						433' @ 1603, add jt; begin 1613
		C-45			440': as above, more sandstone	435' @ 1615
						440' @ 1620
						445' @ 1624
	450	C-46			450': as above, more sandstone, including light gray (5Y7/1) very fine sandstone, non-calcareous	450' @ 1626
						455' @ 1629
		C-47			460': as above, more micaceous	460' @ 1632
						464' @ 1639, add jt; begin 1644
	470	C-48			470': sandstone, reddish-brown, non-calcareous, slight porosity; very fine sand, subround; no gray sandstone; moderately indurated.	465' @ 1645
						470' @ 1650
		C-49			480': as above	475' @ 1654
						480' @ 1659
						485' @ 1703
	490	C-50			490': as above	490' @ 1706
						495' @ 1710
						496' @ 1712, end drilling 7/11/05
		C-51			500': as above	begin drilling 0950 7/12/05
						500' @ 0957
	510	C-52			510': as above	505' @ 1002
						510' @ 1007
						515' @ 1013
		C-53			520': as above	520' @ 1020
						525' @ 1027
						527' @ 1030, add jt; begin 1039
					530': see next page	530' @ 1043
	530	C-54				

Hole ID: SNL-6A | CORE LOG (cont. sheet) | Sheet 5 of 14

Logged by: Dennis W. Powers, Ph.D. | Date: 7/12/05

Run Number	Depth (ft)	% Recovered	RQD	Profile (Rock Type)	Description	Remarks
	530				530': Sandstone, weak red to gray, very fine to medium grains, (5Y7/1, light gray) subround to round, 1-2% dark opaque minerals, no mica; some reddish-brown mudstone; not very calcareous 540': Sandstone, weak red, no gray; very fine to fine, subround, slight mica; silty; not very calcareous	
		C-55				
	550	C-56			550': Sandstone, weak red, gray, with irregular pores to ~1mm in gray sandstone; with some dark reddish brown mudstone.	
		C-57			558' Base of Dockum Group (Santa Rosa Formation?) Top of Dewey Lake Formation 560': Siltstone, sandy, red (2.5YR4/8) with very small gray spots; calcite in fractures; some gray sandy siltstone; some fibrous gypsum	
	570				570': no sample	
		C-58			580': Sandstone, weak red, similar to 540', some hematitic staining on surfaces; non-calcareous; no fibrous gypsum	
	590	C-59			590': Siltstone, sandy, weak red; similar to 560'; and very fine sandstone, weak red, some gypsum	
		C-60			600': as above, gray spots larger	
	610	C-61			610': as above	
		C-62			620': as above, little sandstone; gray spots limited; cuttings show gray laminae in chips	
	630	C-63			630': as above, some very fine sandstone	
		C-64			640': as above	
	650	C-65			650': as above	
		C-66			660': as above	
	670	C-67			670': as above	
		C-68			680': as above, plus gray sandstone, fine to medium, well-rounded, few opaques; poikilotopic gypsum crystals to ~1/4 inch	
	690	C-69			690': similar to 670'	

Hole ID: SNL-6A | CORE LOG (cont. sheet) | Sheet 6 of 14

Logged by: Dennis W. Powers, Ph.D. | Date: 7/12/05; 7/13/05

Run Number	Depth (ft)	% Recovered	RQD	Profile (Rock Type)	Description	Remarks
	690					
		C-70			700': as above, more siltstone	
						end 712' at 1600 7/12/05
	710	C-71			710': as above	
		C-72			720': as above	7/13/05 apparent water level @ 501.5' inside pipe - 5.25' to pad with 615' pipe and bit in hole at 0810 MDT
	730	C-73			730': as above	grab sample of water specific gravity < 1.005 g/cc
		C-74			740': as above	
	750	C-75			750': as above	
		C-76			760': as above	
	770	C-77			770': as above	
		C-78			780': as above	
	790	C-79			790': as above, good examples of fibrous gypsum and both walls of fracture, sandier	
		C-80			800': as above at 780', more gray layering	
	810	C-81			810': as above, with very fine sandstone	
		C-82			820': as above, sandstone increasing	
					Fining upwards	
	830	C-83			830': as above, sandstone	began drilling with faster rotations; smaller cuttings
		C-84			840': siltstone, less sand	
	850	C-85			850': as above	

Hole ID: SNL-6A | CORE LOG (cont. sheet) | Sheet 7 of 14

Logged by: Dennis W. Powers, Ph.D. | Date: 7/13/05-7/14/05

Run Number	Depth (ft)	% Recovered	RQD	Profile (Rock Type)	Description	Remarks
	850					
		C-86			860': mainly siltstone, some sandstone	
	870	C-87			870': as above, more sandstone	end drilling 875' on 7/13/05
		C-88			880': as above	begin drilling 875' on 7/14/05
	890	C-89			890': as above	
		C-90			900': mostly fine sandstone, some siltstone	
					fining upward	
	910	C-91			910': little gypsum (fine cuttings), mostly siltstone	
		C-92			920': mixed siltstone, sandstone, small sample	
	930	C-93			930': mixed sandstone and siltstone with gypsum	
		C-94			940': mixed, small sample	
	950	C-95			950': mostly sandstone, reddish-brown, little gypsum fining upward	
		C-96			960': mostly siltstone, some sandstone; gray siltstone abundant; gypsum in slickensided fractures	Began using more EZmud®; cuttings larger
	970	C-97			970': as above, more siltstone	
		C-98			980': as above	
	990	C-99			990': as above	
		C-100			1000': as above	
	1010	C-101			1010': as above	

Hole ID: SNL-6A | CORE LOG (cont. sheet) | Sheet 8 of 14

Logged by: Dennis W. Powers, Ph.D. | Date: 7/14/05

Run Number	Depth (ft)	% Recovered	RQD	Profile (Rock Type)	Description	Remarks
	1010					
		C-102			1020': as above	
	1030	C-103			1030': as above	
		C-104			1040': as above	
					1046' Base of Dewey Lake Formation Top of Rustler Formation	
	1050	C-105			1050': anhydrite, very pale brown (10YR8/3); fine crystalline	
					1060': no sample	
		C-106			1065': anhydrite, as above	
	1070	C-107			1070': as above	end drilling to begin coring
	1090					

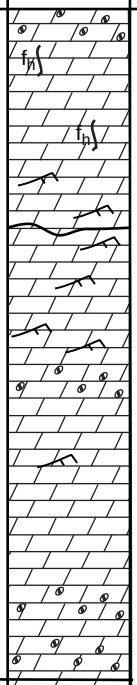
Hole ID: SNL-6A — CORE LOG (cont. sheet) — Sheet 9 of 14

Logged by: Dennis W. Powers, Ph.D. — Date: 7/15/05; 7/18/05

Run Number	Depth (ft)	% Recovered	RQD	Profile (Rock Type)	Description	Remarks
1	1070	cut 28', recovered 22.3'	all segments >4"; RQD - 100.0		1075.9-1070': anhydrite and gypsum, light gray to white, generally fine crystalline, laminar bedding from 0.04 to 0.4 inch, some bedding to ~1 inch; some planes appear stylolitic, and surface pores 0.04 inch indicate probable halite dissolved by drilling; pseudomorphs of swallowtail gypsum at 1074.7' formed on ridge; bedded and small nodules below 1075'.	
					A-5	
	1075				1075.9' 1077-1075.9': argillaceous siltstone, similar to 1083', no apparent halite	
				? lost in coring?	M-4	based on log of adjacent oil well, core loss attributed to mudstone. Core marked from top to bottom.
	1080					
					1084-1083': siltstone, argillaceous, dark reddish-brown (5YR3/3), with some halite	1093.4-1093.6' - narrow halite-filled fracture
	1085				1088.3-1084': halite, generally clear but brownish tint, fine to very coarse (some >1"); common displacive margins, but corroded margins appear more common upward with reddish-brown argillaceous siltstone increasing upward.	
					H-4	
					1088.3' 1093.3-1088.3': halite, generally clear and very coarse (up to 1") to medium (~0.25") with minor or trace fine brownish halite; with gray siltstone (as below) in intercrystalline positions and zones with well-developed displacive margins. Poorly displayed possible corrosion surfaces. Reddish surface mud from drilling.	lower core run 1 marked from bottom up
	1090					
					1093.3' 1094.6-1093.3': siltstone, gray (5Y6/1), non-calcareous, moderately indurated, laminar bedding with slight cross-cutting; white gypsum at 1093.4' and 1093.8';	
					1094.6' narrow halite-filled fracture 1093.6-1093.4'; sharp basal contact, slight erosion	
	1095				1097.0-1094.6': anhydrite, dark to medium gray; laminar wavy beds to ~0.25 inch, common small vertical gypsum or pseudomorphs after gypsum in laminae ~0.25 inch thick, bounded by 0.04 inch dark gray laminae. Some surface pitting suggests some halite pseudomorphs after gypsum. Thin laminae near top without pseudomorphs.	end coring 7/15/05 at 1098'
					1098' 1101.7-1097.0': anhydrite with fine carbonate/organic laminae, as below, and gypsum anhydrite laminae.	
2	1100	cut 30', recovered 30' (100%)	0.6' in segments <4"; RQD = 98.0		A-4 1101.8-1101.7': carbonate laminae 1102.3-1102': small gypsum pseudomorphed by halite 1102.4-1102.3': carbonate laminae 1104.4-1102.4': similar to 1107.5-1104.6' 1104.6-1104.4': carbonate laminae 1107.5-1104.6': Fine carbonate/organic laminae (~1/64") and thin laminae (1/8-1/2") of gypsum or anhydrite and	begin coring 7/18/05 at 1098'
	1105				1107.5' bedded nodular sulfate	
					Base of Forty-niner Top of Magenta Dolomite	
	1110					

Hole ID: SNL-6A | CORE LOG (cont. sheet) | Sheet 10 of 14

Logged by: Dennis W. Powers, Ph.D. | Date: 7/18/05; 7/22-23/05

Run Number	Depth (ft)	% Recovered	RQD	Profile (Rock Type)	Description	Remarks
2	1110 1115 1120 1125	cut 30', recovered 30'	28.9' in segments >4"; RQD - 96.3		1129-1107.5': dolomite, gypsiferous, sandy, generally light gray to light olive gray (5Y7/2-6/2); well-laminated to cross-laminated, with fine laminae as thin as ~1/32" in sets of 1/2" and thicker. Tends to be darker, more brown upward, e.g. 2.5Y6/2. Upper contact sharp, but some carbonaceous laminae and thin beds occur in overlying A-4. Base not cored. Halite in fractures to 1114.9', may be source of surface porosity at 1115.1-1114.9'. 1109.8-1107.5': bedding more planar with low-angle cross-cutting; wavy, no ripples. 1111.1-1109.8': starved ripples without gypsum in subhorizontal beds with gypsum nodules; organic/clay-rich laminae to 1/8". 1114.8-1111.1': similar to 1119.8-1115.1' 1114.8': organic layer over ~1/8-1/4" halite at top of porous zone, poikilotopic halite on surface 1115.1-1114.8': sandy, pores on surface: halite replacement of tiny oolites?; erosional surface 1115.1 with 2" relief. 1119.8-1115.1': set size larger, ripples with cross-laminae to 1/2" high, stronger cross-cutting boundaries with relief 1/2-1"; NaCl at 1115.3' in ripple 1124.9-1119.8': laminae near horizontal, sets thin; some ripples, slight cross-cutting set bounds wavy 1128-1124.9': laminae subhorizontal to wavy, slight cross-cutting set boundaries.	Decided not to core basal zone because of time and labor for little additional return.
	1130 1135 1140 1145 1150				erosional surface 1129' 1111.1-1109.8': small white gypsum nodules, up to 1/4" at top 1120.3-1119.8': tiny white gypsum nodules (?) to 1/8" 1128-1124.9': tiny white gypsum nodules (?) to 1/8" Base of Magenta Dolomite Top of Tamarisk (A-3) ~1129-1181': anhydrite, gray to white, fine cuttings	end coring 7/18/05 begin reaming 7/22/06 no cuttings samples retained 1129-1140' end drilling 7/22/05 at 1143'; begin drilling 7/23/05

Hole ID: SNL-6A | CORE LOG (cont. sheet) | Sheet 11 of 14

Logged by: Dennis W. Powers, Ph.D. | Date: 7/23/05; 7/26/05

Run Number	Depth (ft)	% Recovered	RQD	Profile (Rock Type)	Description	Remarks
2	1150	C-108			anhydrite, gray to white, fine cuttings	
	1160	C-109				
	1170	C-110		A-3		end drilling at 1170' on 7/23/05; begin drilling 7/26/05
	1180	C-111				
				1182'	1292-1188' halite, clear, includes some cuttings in mud column; halite cuttings to 0.25 inch	drilling rate increase at 1182'
				H-3		
	1190	C-112				
	1200	C-113				
					1205-1203': harder drilling, likely anhydrite, cuttings not significant	
	1210	C-114				
	1220	C-115				
					1225-1223.5': harder drilling, likely anhydrite, cuttings not significant	
	1230	C-116				

Hole ID: SNL-6A | CORE LOG (cont. sheet) | Sheet 12 of 14

Logged by: Dennis W. Powers, Ph.D. | Date: 7/26/05

Run Number	Depth (ft)	% Recovered	RQD	Profile (Rock Type)	Description	Remarks
	1230					
	1240	C-117				
	1250	C-118			1253-1260': depth approximate; anhydrite and polyhalite	
	1260	C-119				
	1270	C-120				
	1280	C-121				
	1290	C-122				
3					1292' begin coring see next sheet for details	
	1300					
	1310					

Hole ID: SNL-6A | CORE LOG (cont. sheet) | Sheet 13 of 14

Logged by: Dennis W. Powers, Ph.D. | Date: 7/27/05 - 7/28/05

Run Number	Depth (ft)	% Recovered	RQD	Profile (Rock Type)	Description (Note change of scale)	Remarks
	1290				1307.3-1292': halite, slightly argillaceous, with zones of gypsum/anhydrite; halite clear to brownish, very coarse to fine, is arranged in some desiccating upwards sequences with efflorescent salt and corrosion/erosion surfaces (c.s, e.s). Basal 1" of hard clay and carbonate? over undulatory surfaces on anhydrite.	coring with brine mud
3		cut 30', reocovered 30'	0.2' in segments <4" RQD = 99.3		1292' e.s.	
	1295					
					gray and brown clay/silt in halite between corrosion surfaces (c.s.); efflorescent halite below lower surface and upper surface	
	1300				c.s. c.s.	
					argillaceous and slightly gypsiferous from 1302.6-1302.9', over poorly developed surface with corrosion of underlying halite	
					H-3	
	1305					
					1307.3' 1323.8-1307.3': anhydrite, gray	
	1310				A-2	
					1311 - 1307.9': small (<1") halite pseudomorphs after vertical gypsum in beds up to ~1" thick with interbedded fine laminar anhydrite without pseudomorphs. Possible stylolite at 1310.8'? Bedding appears to be undulatory.	
					stylolite?	
	1315				1313.5 - 1311': very large halite pseudomorphs after gypsum growth - up to 2' continuous vertical 1313.5 - 1313.9'; gray anhydrite, fine grained, laminar 1313.9 - 1314.7': laminar gray anhydrite with clay and claystone; laminae cross-cutting, slightly deformed in claystone at top. 1314.7 - 1323.8': gray laminar anhydrite, slightly undulatory, halite-filled small irregular pores that may be remnants of halite pseudomorphs after gypsum; possible bedded nodular texture near top. Basal transition over ~1/2"	
	1320				1322' Base of Tamarisk	
4		cut 5', recovered 4.3'	0.2' in segments <4" RQD = 95.3		1323.8' Top of Culebra 1346.6-1323.8': Dolomite, light brown to gray, bedded	
	1325				1326.4-1328' irregular horizontal bedding 1-2" with very fine laminae - above fracture area	
					1327'	
5					1328 - 1337.5' irregular to subvertical fractures with halite fill. Halite-filled fractures most dense 1335-1337', decrease upward	
	1330					

Hole ID: SNL-6A | CORE LOG (cont. sheet) | Sheet 14 of 14

Logged by: Dennis W. Powers, Ph.D. | Date: 7/28/05

Run Number	Depth (ft)	% Recovered	RQD	Profile (Rock Type)	Description	Remarks
5	1330	cut 30', recovered 29.5'	4.5' in segments < 4" RQD= 84.7			coring with brine mud
					1335 - 1333.8' Sandy, bioturbated?, fragments of pelecypod shells	
	1335				1335-1336' oölitic? nodular anhydrite	
					1339.5-1336' Sandy, planar beds, cross-cutting	
	1340				1342.4-1339.5' irregular laminae to planar bedding	
					1346.6-1342.4'; light to dark dolomite, thin beds to laminae, general slight inclination, slight cross-cutting; vertical to subvertical, planar to irregular fractures filled with halite.	
	1345				1346.6' Base of Culebra / Top of Los Medaños	
					1351.6-1346.6': claystone, silty, generally dark gray with reddish-brown hues; well-preserved thin horizontal laminae. Near-vertical planar fracture, no fill, 1347.5-1350.0' in very dark gray zone (organic zone?). Gypsiferous at 1350.6' with gypsiferous fracture fill	
	1350				1351.6'	
					1354.2-1351.6': siltstone, argillaceous; generally reddish brown; clasts of reddish-brown siltstone and gypsum, generally angular, up to 2", probably increasing in size upward. 45 degree fractures with narrow separation filled with gypsum. Sharp basal contact is undulatory.	
	1355				1354.2'	
					~1356-1354.2': halite, coarse to very coarse upward, more clay in basal 1'	
					1357	
	1360					

Appendix D
Permitting and Completion Information

A case file for SNL-6 (C-3151) containing official documents is maintained by the land management coordinator, Environmental Monitoring and Hydrology Section of Washington Regulatory and Environmental Services for the WIPP Project. Selected documents are reproduced here for ease of access. Originals have been reduced to fit page formats.

As noted in the text, all official correspondence concerning permitting and regulatory matters should refer to the New Mexico State Engineer permit number C-3151.

Dennis W. Powers, Ph. D.
Consulting Geologist

July 28, 2005

Ron Richardson
Field Lead
WRES

Rick Beauheim
Hydrology Lead
Sandia National Laboratories

Re: Screen Interval for Culebra Dolomite Member in SNL-6

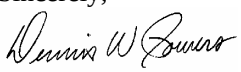
The information regarding the Culebra in SNL-6 indicates that the best interval to screen is from 1346.0–1319.9 ft below the top of the surface conductor casing. This decision is based on geophysical logs completed on July 28, 2005 (see attached figure) and cores from SNL-6.

These are factors considered in this decision for SNL-6:

- The Culebra interval, based on the density log, is from 1324–1346.5 ft. The natural gamma-neutron tool could not be dropped past ~350 ft where the Santa Rosa Formation persistently squeezed the drillhole partially shut during inactivity. The Culebra is 22.5 ft thick, somewhat thinner than average around the WIPP site. Coring indicated 22.8 ft of Culebra, with excellent recovery.
- Core across the transition from Culebra to Los Medaños was recovered intact. The gray silty claystone immediately below the Culebra was indurated, showing fine laminae and no deformation. It is not expected to interfere with the screen interval.
- The screened or slotted section of the casing joint is 26.1 ft long, beginning ~1.7 ft above the base of the joint. The screened interval will incorporate all of the Culebra and part of the basal Tamarisk anhydrite (A-2). A-2 is not visibly porous; halite is present as pore fillings and as pseudomorphs after original gypsum crystals.
- Laminated claystone, siltstone, and halite (M-2/H-2) below the Culebra were sampled to establish their presence and characteristics. Salt was encountered ~7.6 ft below the base of the Culebra. The siltstone and claystone ~2 ft below the Culebra showed near-vertical planar fractures without fill in otherwise undeformed laminar sediment.
- SNL-6 was cored to ~1357 ft. The final reamed/drilled depth before casing is 1360 ft, and the sump below the screen will be adjusted to fit. Because of the depth and fluid in the drillhole, it is not practical to seal off the bottom of the hole with HolePlug®. There is no apparent danger of dissolving halite with Culebra water considering there is halite in narrow fractures and porosity of the Culebra at SNL-6.
- Geophysical logs and core indicate A-2 is intact and separates the Culebra from Tamarisk halite (H-3) by 16.5 ft. The base of H-3 is at 1307.3 ft in core. The thin silty interval at ~1314 ft in A-2 will not be problem at the zone near the top of the gravel pack.
- The sand/gravel pack should be placed from the base of the reamed drillhole to a depth of ~1314 ft. The bentonite seal will be placed from ~1314–1309 ft, and the annulus will be cemented from the top of the HolePlug® ft to the surface.

I believe this letter summarizes the hydrological and geological justification for setting the screened interval and preparing SNL-6 for completion.

Sincerely,



Dennis W. Powers

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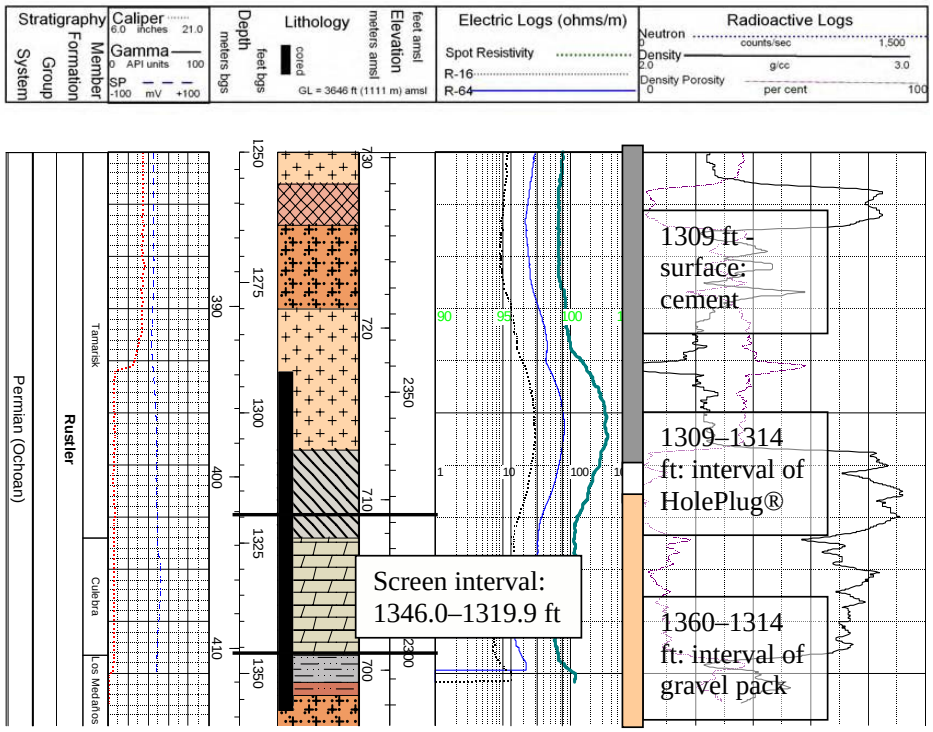
Dennis W. Powers, Ph. D.
Consulting Geologist

July 28, 2005

Partial Geophysical Log of SNL-6
Showing Completion Intervals



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Dennis W. Powers, Ph. D.
Consulting Geologist

August 23, 2005

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Washington TRU Solutions
Carlsbad, NM 88220

Storage and Retention of Cores and Rock Samples from SNL-6

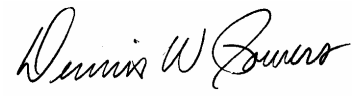
Background
Cores and cutting samples have been collected from drillhole SNL-6 in support of the drilling and testing program to investigate the hydrology of the Culebra Dolomite Member of the Rustler Formation as well as other units of hydrogeological significance to the program. These samples were collected under my supervision, and the chain-of-custody has been maintained by me or WRES personnel. SNL-6 is being drilled, completed, and tested under WTS contract provisions and under provisions in the hydrology program plan (SNL. 2003. Program Plan, WIPP Integrated Groundwater Hydrology Program, FY03-09, Revision 0. March 14, 2003. ERMS 526671).

Core and Cuttings Storage Conditions
There is no sample or core testing planned for SNL-6 requiring abnormal handling, preservation conditions, or immediate action to obtain test information. As a consequence, these samples and cores can be maintained in your current core storage facilities. Many of the cores obtained from SNL-6 are likely to be accessed in the next few months for further geologic studies to establish more details of stratigraphic, sedimentologic, and diagenetic conditions and events. These studies, if carried out, will be carried out under a formal plan, most likely developed under QA requirements of Sandia National Laboratories.

Core and Cuttings Retention Periods
It is recommended that cores obtained from SNL-6 be maintained indefinitely under normal storage conditions because of their relevance to hydrology and monitoring programs. The cores can be accessed for observations, and they can be removed for further laboratory study, including possible destruction, under a plan with appropriate management and QA approval.

It is recommended that cuttings samples be retained under normal storage conditions through the approval by EPA of the second CRA. The cuttings are commonly very fine in shallow sections and add little to the geologic record from initial observations as well as geophysical logs. Cuttings may be accessed for observation, and they may be removed for further laboratory study, including possible destruction, under a plan with appropriate management and QA approval.

Supplemental Information
Descriptive core logs and digital photographs of cores with a photograph log will be provided to you on CD-ROM format in accessible formats when the content has been reviewed for the basic data report for SNL-6.



Dennis W. Powers

Copy to:
Ron Richardson, *Environmental Monitoring*, WRES
Richard L. Beauheim, *Hydrology Lead*, Sandia National Laboratories

140 Hemley Road, Anthony, TX 79821
Telephone: (915) 877-3929 E-mail: dwpowers@evaporites.com *FAX: (915) 877-5071*

Dennis W. Powers, Ph. D.
Consulting Geologist

August 2, 2005

Ron Richardson
Field Lead
WRES

Rick Beauheim
Hydrology Lead
Sandia National Laboratories

Drilling Decision for SNL-6

Basic Chronology

SNL-6 was cored and drilled (11-inch-diameter bit) to a total depth (TD) of 1360 ft, which is stratigraphically in the upper Los Medaños Member of the Permian Rustler Formation, just below the target horizon of the Culebra Dolomite Member. After coring was complete on July 28, geophysical logs were obtained from SNL-6. The caliper log from SNL-6 shows that the diameter of the drillhole was reduced to little more than 9 inches through a section from about 297–506 ft. A density log was obtained sufficient for determining completion intervals, but it was not possible to get the lighter natural gamma-neutron tool through this interval. Following logging, SNL-6 was reamed to 11 inches, reaching TD on July 29. The tremmie line was placed in the hole and then 5 ½ inch fiberglass reinforced plastic (FRP) casing was run into the hole with a screened interval across the Culebra (1324-1346.5 ft below the surface). Portions of the drillhole squeezed in sufficiently after reaming to prevent pulling the tremmie line in order to fill the annulus. The FRP casing was removed from the drillhole late July 29 and early July 30 and salvaged. The tremmie line could not be pulled from the hole. After a shutdown over the weekend, the tremmie line was washed down and pulled from the drillhole on August 2, 2005. The drillhole is to be cemented from TD to surface late today and abandoned.

Cause of Problems

Cuttings logged by Dennis W. Powers, and the geophysical logs, show that the main zone of squeezing and hole problems is apparently through the interval from about 297–506 ft. This interval is within the lower Santa Rosa Formation, and a small amount of water comes from it. Cuttings indicate that there is considerable micaceous siltstone and sandstone through this section of the drillhole, and the units can be poorly indurated. Cuttings also began to show signs of moisture at about 380 ft, and water was determined to be entering the drillhole below these depths. Water levels were measured on the mornings of 7/12, 7/13, 7/14, 7/15, and 7/18 with TD at depths from 497–1070 ft. The highest water level, on 7/12, was about 375 ft. Calculated inflow from later measurements indicate a range from about 1.1 gallons per minute (7/13) to 0.8 gallons per minute (7/18). It is likely that the uppermost saturated level is about 375 ft. The data seem to indicate that no water is coming from the Dewey Lake Formation or the upper Rustler Formation. It is likely that this water is assisting the squeezing of the finer grained lithologies through part of the interval, and the water also complicated drilling. As drilling proceeded, some even shallower intervals and deeper intervals began to require some recutting every time the bit and drillpipe were run into the hole for daily activities.

Solutions Attempted

Early drilling was done with compressed air. After Santa Rosa water was encountered, drilling proceeded with air and mist. Following coring of the upper Rustler, hole conditions began to deteriorate and fill was increasing. Halite had been encountered in the upper Rustler,

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Dennis W. Powers, Ph. D.
Consulting Geologist

and the rig was reconfigured to drill with brine to stabilize the drillhole. Because polymers proved insufficient to raise the cuttings, the mud viscosity was increased with Zeogel, and the hole was then cored and drilled to TD. In the final few days, 24-hour operations were begun because of the delays in tripping completely out and the need to recut portions of the hole every days while tripping in. Despite these extra measures, the final completion of the hole proved problematic. Rather than risking a poorly completed well or a well plugged and abandoned with casing and/or tremmie pipe in the hole, it was decided to cement the drillhole from TD to surface and drill a new hole, based on the knowledge gained of the ground conditions that exist at this location.

Prospective Drilling and Completion of SNL-6

A complete core of the Culebra Dolomite was recovered. There are a few fractures in the unit, but fractures are apparently all filled with halite. There are pore fillings of anhydrite and halite also within the Culebra. By inspection and by analogy with other similar wells, the Culebra is expected to have very low transmissivity. Fluid flow should be very limited, and it seems unlikely that a pumping test will be practical at this location. As a consequence, the initial plan of completing the well with a larger diameter (5 ½ inch) FRP casing isn't necessary or helpful. For drilling an adjacent hole and completing the well, a smaller diameter (e.g. 2 ½ inch) casing is recommended. For a drillhole adjacent to the abandoned SNL-6, stratigraphic intervals, completion depths, and materials (e.g., sand pack, bentonite seal, and cement to the surface) remain the same.

Based on discussions with the driller (Ronnie Keith, West Texas Water Well Service), field lead (Ron Richardson), and hydrology lead (Rick Beauheim) the following basic program will be followed to provide a completed well to the Culebra on the SNL-6 drillpad:

- Drill 12 ¾ inch hole with air to about 600 ft, place 8 ¾ inch steel casing, and cement back to surface to control the shallow zone that caused problems by squeezing. This should also control the inflow of ~ 1 gpm from the Santa Rosa.
- Drill 7 7/8 inch hole with air to TD (about 1360).
- Set 2 ½ inch FRP casing with screen interval from 1346 ft to about 1320 ft with 8-10 ft of blank casing and endcap below screen.
- Run sand/gravel pack from TD to about 1314 ft, bentonite seal from about 1314 ft to 1309 ft, and cement annulus from 1309 ft to surface.
- Complete surface configuration with about 2 ft stickup, secured housing, and cement pad.

I believe this letter summarizes the background that led to abandoning and plugging the initial hole drilled on the SNL-6 location. The plan to drill and complete a smaller diameter hole, with control of the problem zone, should allow an efficient and satisfactory completion of the Culebra for long-term monitoring.

Sincerely,

Dennis W. Powers

140 Hemley Road, Anthony, TX 79821
Telephone: (915) 877-3929 E-mail: dwpowers@evaporites.com *CELL: (915) 588-7901*

SNL6
Revised August 196

IMPORTANT - READ INSTRUCTIONS ON BACK BEFORE FILLING OUT THIS FORM

APPLICATION FOR PERMIT

To appropriate (explore & monitor) the Underground Waters of the State of New Mexico

Date Received 02-07-05 File No. C-3151

1. Name of applicant U.S. Department of Energy, Carlsbad Field Office, WIPP
   Mailing address P.O. Box 3090, Carlsbad, New Mexico 88221-3090
   City and State Carlsbad, New Mexico, 88221

2. Source of water supply Artesian - Culebra (Artesian or shallow water aquifer), located in Carlsbad, (Name of underground basin)

3. The well is to be located in the se ¼ nw ¼ se ¼, Section 7 Township 21 South Range 32 East N.M.P.M., or Tract No. n/a of Map No. n/a of the Capitan District, on land owned by U.S. Department of the Interior, Bureau of Land Management

4. Description of well: name of driller West Texas Water Well Service
   Outside Diameter of casing < 7 inches; Approximate depth to be drilled 1600 then plugged back to 1400 feet;

5. Quantity of water to be appropriated and beneficially used N/A (Consumptive use, diversion) acre feet,
   for N/A purposes.

6. Acreage to be irrigated or place of use N/A acres.

Subdivision	Section	Township	Range	Acres	Owner

7. Additional statements or explanations The intent of this application is to provide authorization to drill a groundwater monitoring well in support of Performance Assessment for the U. S. Department of Energy's Waste Isolation Pilot Plant. This well will be completed in the Culebra Dolomite Member of the Rustler Formation and will not be used to appropriate water for beneficial use. Initial pump tests will be conducted, not to exceed 30 days @ less than or equal to, 20 gal/min. Thereafter, the subject well will be used for water level measurements only.

I, Harold Johnson, affirm that the foregoing statements are true to the best of my knowledge and belief and that development shall not commence until approval of the permit has been obtained.

U.S. Department of Energy, Carlsbad Field Office, Permittee,

By: Harold Johnson

Subscribed and sworn to before me this 7th day of Feb, A.D., 2005

My commission expires Oct. 3, 2005 Sharon Warren-Briggs
Notary Public
#323371

John R. D Antonio, Jr., P.E.
State Engineer

Roswell Office
1900 WEST SECOND STREET
ROSWELL, NM 88201

STATE OF NEW MEXICO
OFFICE OF THE STATE ENGINEER

Trn Nbr: 323371
File Nbr: C 3151

February 10, 2005

HAROLD JOHNSON
U.S. DEPT OF ENERGY
CARLSBAD FIELD OFFICE, WIPP
P.O. BOX 3090
CARLSBAD, NM 88221-3090

Greetings:

Enclosed is your copy of the Exploratory / Monitoring Permit which has been approved. Your attention is called to the Specific and General Conditions of Approval of this permit.

In accordance with General Condition C, a well record shall be filed in this office ten days after completion of drilling. The well record is proof of completion of well. IT IS YOUR RESPONSIBILITY TO ASSURE THAT THE WELL LOG BE FILED WITHIN 10 DAYS OF DRILLING OF THE WELL.

This permit will expire on or before 02/28/06, unless the well has been drilled and the well log filed in this office.

Sincerely,

Mike Stapleton
(505)622-6467

Enclosure

cc: Santa Fe Office

explore

UNIQUE #	DOE DATE	DATE REC'VD	ADDRESSEES
CT00610	548100	FEB 1 1 2005	H Johnson w/orig

NEW MEXICO STATE ENGINEER OFFICE
PERMIT TO EXPLORE

SPECIFIC CONDITIONS OF APPROVAL

2 The well shall be constructed to artesian well specifications and the State Engineer shall be notified before casing is landed or cemented

4 No water shall be appropriated and beneficially used under this permit.

B The well shall be drilled by a driller licensed in the State of New Mexico in accordance with Section 72-12-12 New Mexico Statutes Annotated.

C Driller's well record must be filed with the State Engineer within 10 days after the well is drilled or driven. Well record forms will be provided by the State Engineer upon request.

C1 A complete and properly executed Well Record on the form provided by the State Engineer shall be filed not later than ten (10) days after completion of the well.
Test data shall be filed not later than ten (10) days after completion of the test(s).

LOG The Point of Diversion C 03151 must be completed and the Well Log filed on or before 02/28/2006.

ACTION OF STATE ENGINEER

Notice of Intention Rcvd: Date Rcvd. Corrected:
Formal Application Rcvd: 02/07/2005 Pub. of Notice Ordered:
Date Returned - Correction: Affidavit of Pub. Filed:

This application is approved provided it is not exercised to the detriment of any others having existing rights, and is not contrary to the conservation of water in New Mexico nor detrimental to the public welfare of the state; and further subject to the specific conditions listed previously.

Witness my hand and seal this 10 day of Feb A.D., 2005

John R. D Antonio, Jr., P.E. , State Engineer

By: _____
Art Mason

Trn Desc: C 3151 File Number: C 03151
Trn Number: 323371

page: 1

Number of this permit_____ _____

ACTION OF STATE ENGINEER

Alter notice pursuant to statute and by authority vested in me, this application is approvedprovided it is not exercised to the detriment of any others having existing rights; further provided that all rules and regulations of the State Engineer pertaining to the drilling of_____ wells be complied with; and further subject to the following conditions:_____

see attached conditions of approval

Proof of completion of well shall be filed on or before N/A, 20xx

Proof of application of water to beneficial use shall be filed on or before N/A, 20xx

Witness my hand and seal this 10 day of February, A.D., 2005

John R. D'Antonio, Jr., P.E., State Engineer

By:_____

INSTRUCTIONS

This form shall be executed, preferably typewritten, in triplicate and shall be accompanied by a filing fee of $25.00. Each of triplicate copies must be properly signed and attested.

A separate application for permit must be filed for each well used.

Secs. 1-4 - Fill out all blanks fully and accurately.

Sec. 5 - Irrigation use shall be stated in acre feet of water per acre per annum to be applied on the land. If for municipal or other purposes, state total quantity in acre feet to be used annually.

Sec. 6 - Describe only the lands to be irrigated or where water will be used. If on unsurveyed lands describe by legal subdivision "as projected" from the nearest government survey corners, or describe by metes and bounds and tie survey to some permanent, easily located natural object.

Sec. 7 - If lands are irrigated from any other source, explain in this section. Give any other data necessary to fully describe water right sought.

United States Department of the Interior

Bureau of Land Management
Carlsbad Field Office
620 E. Greene Street
Carlsbad, NM 88220
www.nm.blm.gov

IN REPLY REFER TO:
NM-108365
2805(520)owl

MAR 16 2005

U. S. Dept. of Energy, Carlsbad Field Office
P. O. Box 3090
Carlsbad, NM 88221-3090

RIGHT-OF-WAY RESERVATION AMENDMENT

KNOW ALL MEN BY THESE PRESENTS, that in accordance with section 507 of the Federal Land Policy and Management Act of 1976 (90 Stat. 2781, 43 U.S.C. 1767) that the United States of America acting by and through the U. S. Department of the Interior, Bureau of Land Management, does hereby issue and reserve to the U. S. Department of Energy, Carlsbad Field Office, Waste Isolation Pilot Plant (WIPP), a right-of-way amendment for three additional well pads, and access roads for the expressed purpose of conducting groundwater investigations in support of the WIPP, over the following described real property situated in the Counties of Lea and Eddy, State of New Mexico to wit:

SNL – 6	SNL-8	SNL-15
T. 21 S., R. 32 E., NMPM	T. 22 S., R. 31 E., NMPM	T. 22 S., R. 31 E., NMPM
Sec. 7: Lot 4, and SE¼SW¼, SE¼.	Sec. 14: SE¼SE¼.	Sec. 26: SE¼SE¼.

The well site locations contain approximately 1.551 acres (approximately 150' X 150') and the linear features (roads) contain approximately 6408 feet length, 20 feet width, for 2.975 acres. The combined acreage of the site locations and roads are 4.526 acres.

A plat showing the reservation amendment described above is attached hereto as Exhibit A and made a part hereof.

The right-of-way herein granted and reserved is for the full use of the above described property by the U. S. Department of the Energy, Carlsbad Field Office, WIPP, subject to reasonable rules and regulations of the Secretary of the Interior, and to the following terms and conditions:

1. The facility will be constructed, operated, and maintained in accordance with the details specified in the application submitted February 18, 2005.

2. The Bureau of Land Management retains the right to occupy and use the right-of-way, provided such occupancy and use will not unreasonably interfere with the rights granted herein. The Bureau of Land Management may, if the Department of Energy, Carlsbad Field Office, WIPP concurs, grant rights and privileges for the use of the right-of-way to other compatible users including members of the public and other Government Departments and Agencies, States, and local subdivisions thereof.

3. Department of Energy, Carlsbad Field Office, WIPP, will be responsible for the security and day-to-day operation of the facility.

4. Any resources on lands within the right-of-way shall remain under the jurisdiction of the Bureau of Land Management and may be severed or extracted or disposed of only in accordance with applicable law and regulation of the Secretary of the Interior. The extraction, severance, and disposal of any such resources shall be subject to such stipulations, if any, that the Bureau of Land Management and Department of Energy, Carlsbad Field Office, WIPP, agree are needed to avoid unreasonable interference with the use of the land.

5. When and if the Department of Energy, Carlsbad Field Office, WIPP, no longer needs this amended reservation, if jurisdiction is not transferred to another entity, the Department of Energy, Carlsbad Field Office, WIPP, will rehabilitate the land according to the following specifications.

A. All structures, improvements, debris, etc., will be removed.

B. The land will be returned to the original contour.

C. All disturbed surfaces will be reseeded with a seed mixture conducive with Lesser Prairie Chicken habitat.

D. Attached are Special Stipulations for Site Reclamation.

6. The reservation being amended has a 30-year term, commencing on August 30, 2002.

Tony J. Herrell

Tony J. Herrell, Field Manager
Carlsbad Field Office, BLM

3-15-05
Date

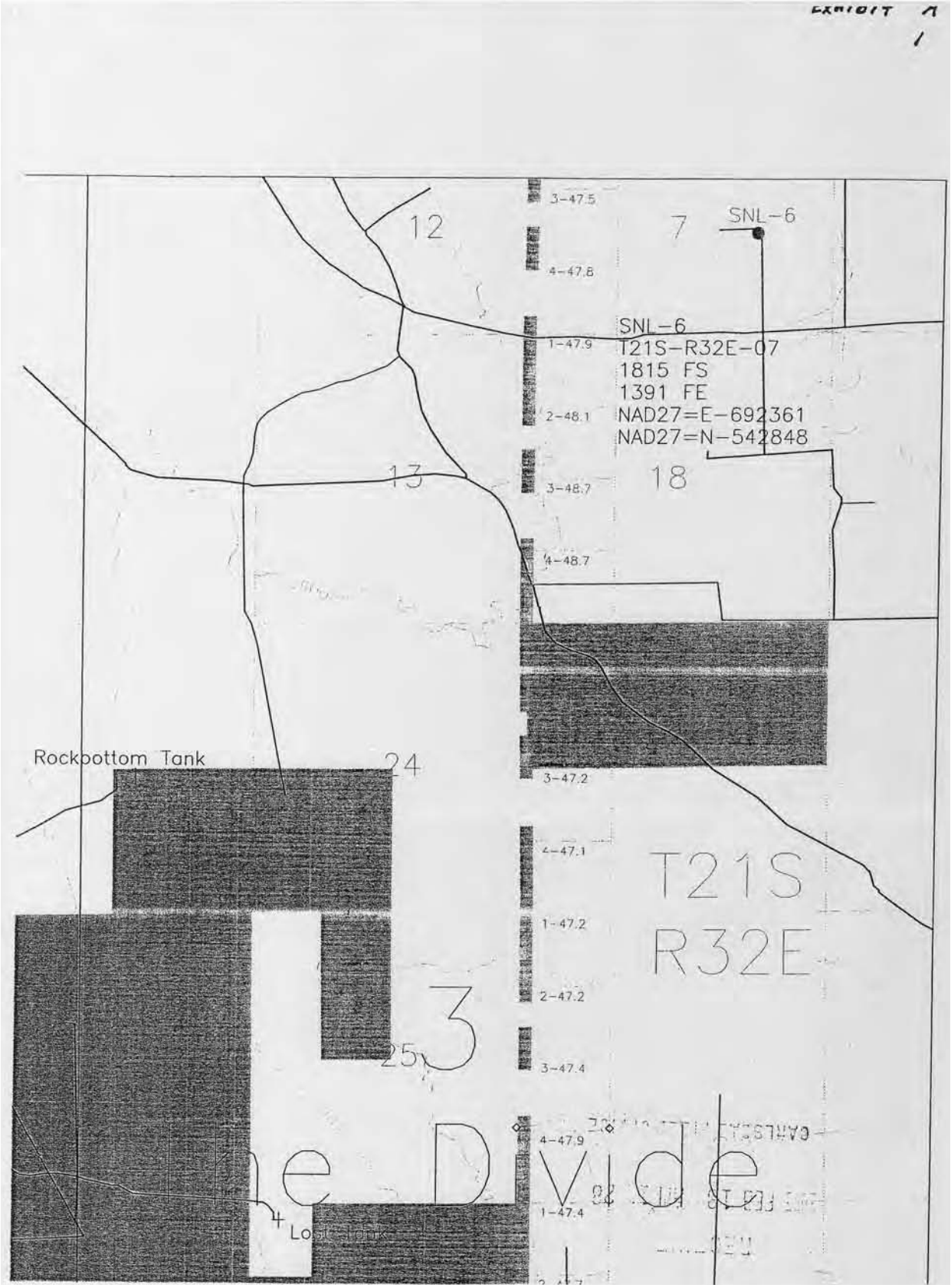


EXHIBIT A
1
12
7
SNL-6
3-47.5
4-47.8
SNL-6
T21S-R32E-07
1815 FS
1391 FE
NAD27=E-692361
NAD27=N-542848
1-47.9
2-48.1
13
18
3-48.7
4-48.7
Rockbottom Tank
24
3-47.2
4-47.1
T21S
R32E
1-47.2
2-47.2
3
25
3-47.4
4-47.9
1-47.4
Lost Tank
Divide

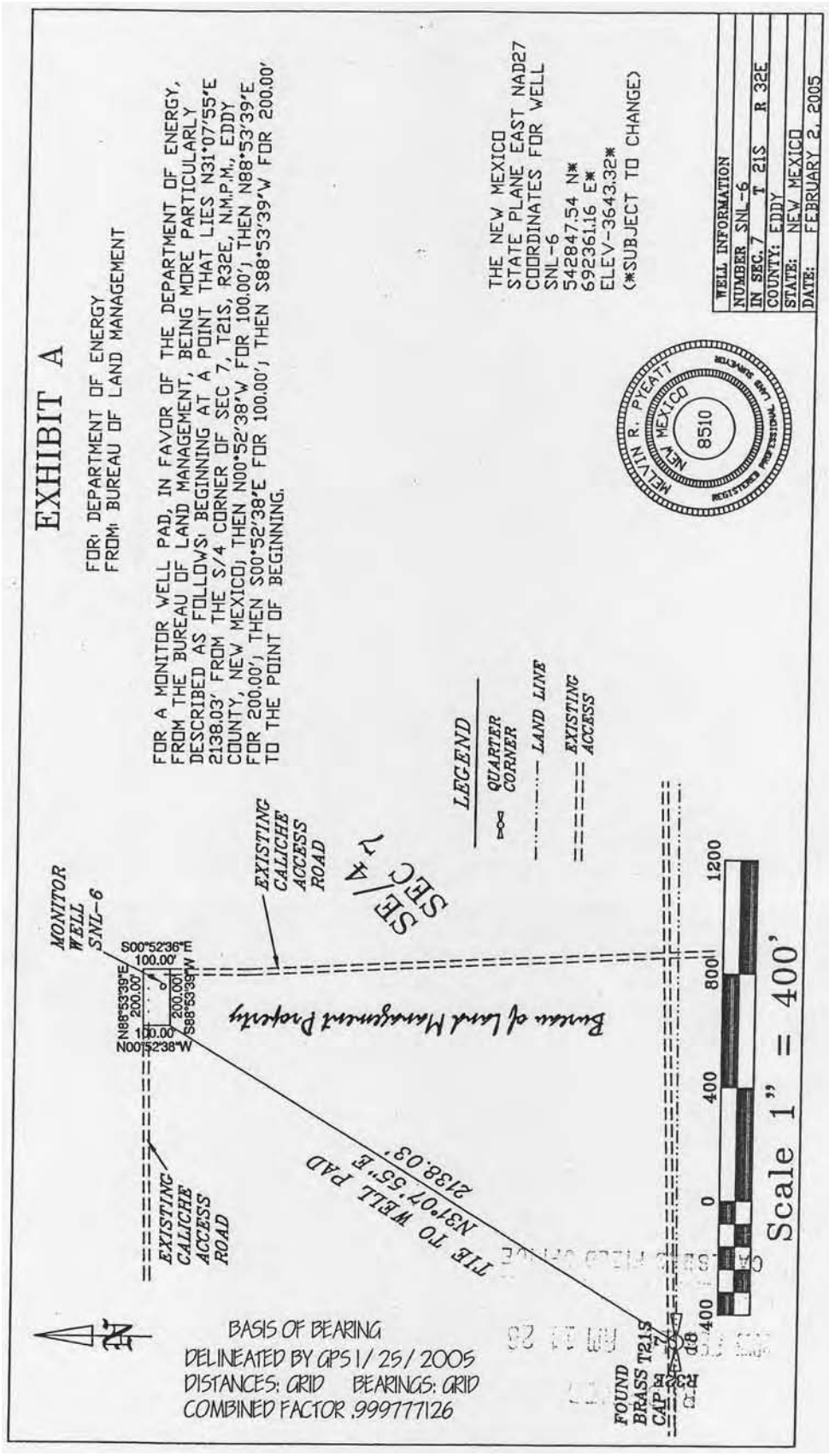


EXHIBIT A
FOR: DEPARTMENT OF ENERGY
FROM: BUREAU OF LAND MANAGEMENT
FOR A MONITOR WELL PAD, IN FAVOR OF THE DEPARTMENT OF ENERGY, FROM THE BUREAU OF LAND MANAGEMENT, BEING MORE PARTICULARLY DESCRIBED AS FOLLOWS: BEGINNING AT A POINT THAT LIES N31°07'55"E 2138.03' FROM THE S/4 CORNER OF SEC 7, T21S, R32E, N.M.P.M., EDDY COUNTY, NEW MEXICO; THEN N00°52'38"W FOR 100.00'; THEN N88°53'39"E FOR 200.00'; THEN S00°52'38"E FOR 100.00'; THEN S88°53'39"W FOR 200.00' TO THE POINT OF BEGINNING.
THE NEW MEXICO STATE PLANE EAST NAD27 COORDINATES FOR WELL SNL-6
542847.54 N*
692361.16 E*
ELEV-3643.32*
(*SUBJECT TO CHANGE)
MELVIN R. PYEATT NEW MEXICO 8510 REGISTERED PROFESSIONAL LAND SURVEYOR
WELL INFORMATION
NUMBER SNL-6
IN SEC. 7 T 21S R 32E
COUNTY: EDDY
STATE: NEW MEXICO
DATE: FEBRUARY 2, 2005
LEGEND
QUARTER CORNER
LAND LINE
EXISTING ACCESS
MONITOR WELL SNL-6
EXISTING CALICHE ACCESS ROAD
S00°52'36"E 100.00'
N88°53'39"E 200.00'
100.00 N00°52'38"W
200.00' S88°53'39"W
SE/4 SEC 7
Bureau of Land Management Property
TIE TO WELL PAD N31°07'55"E 2138.03'
EXISTING CALICHE ACCESS ROAD
BASIS OF BEARING
DELINEATED BY GPS 1/25/2005
DISTANCES: GRID BEARINGS: GRID
COMBINED FACTOR .999777126
FOUND BRASS CAP T21S
Scale 1" = 400'
0 400 800 1200

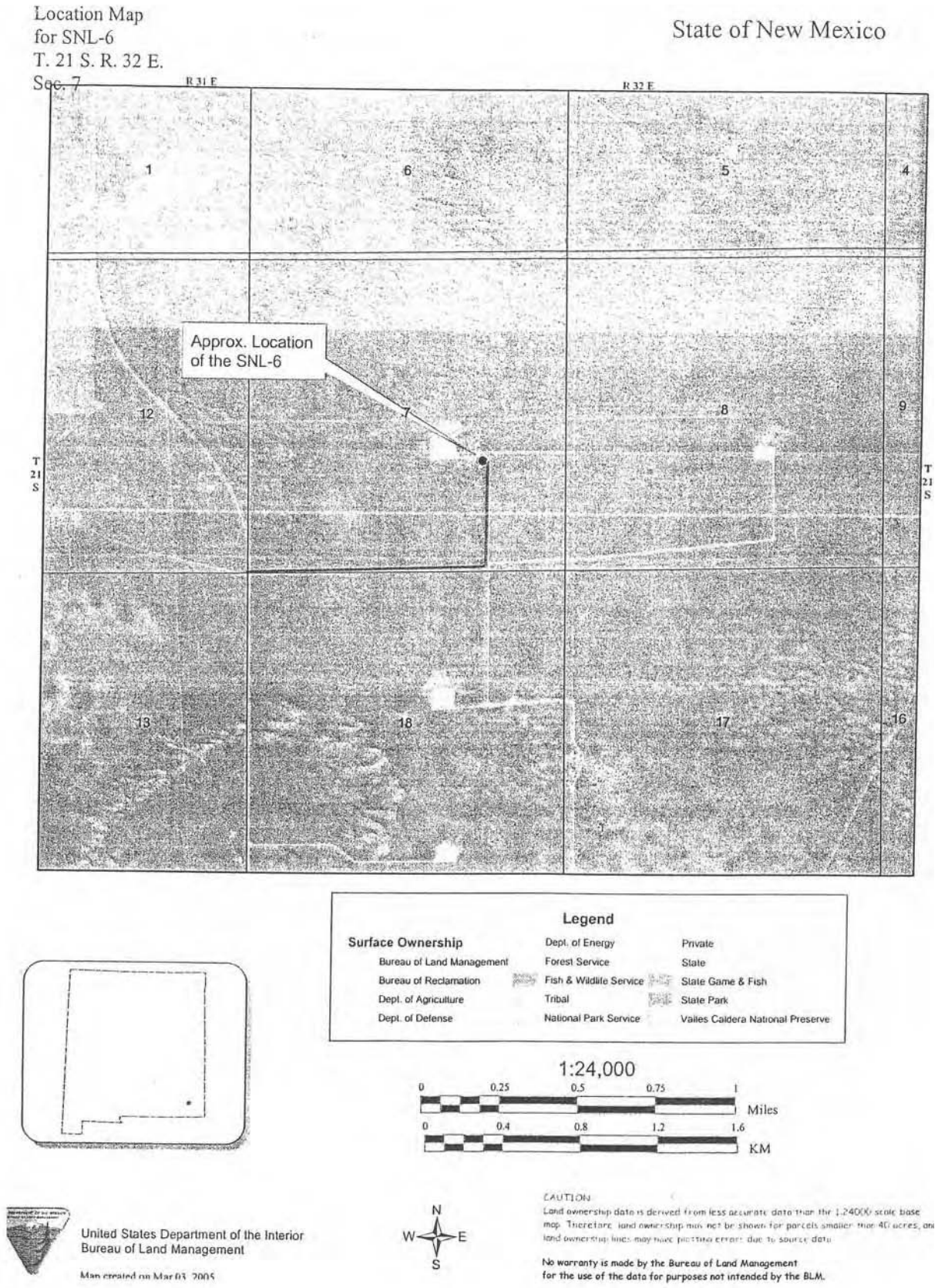

Location Map
for SNL-6
T. 21 S. R. 32 E.
Sec. 7
State of New Mexico
R 31 E
R 32 E
1
6
5
4
Approx. Location
of the SNL-6
12
7
8
9
T
21
S
T
21
S
13
18
17
16
Legend
Surface Ownership
Bureau of Land Management
Bureau of Reclamation
Dept. of Agriculture
Dept. of Defense
Dept. of Energy
Forest Service
Fish & Wildlife Service
Tribal
National Park Service
Private
State
State Game & Fish
State Park
Valles Caldera National Preserve
1:24,000
0
0.25
0.5
0.75
1
Miles
0
0.4
0.8
1.2
1.6
KM
United States Department of the Interior
Bureau of Land Management
Map created on Mar 03, 2005
N
W
E
S
CAUTION
Land ownership data is derived from less accurate data than the 1:24000 scale base map. Therefore, land ownership may not be shown for parcels smaller than 40 acres, and land ownership lines may have plotting errors due to source data.
No warranty is made by the Bureau of Land Management
for the use of the data for purposes not intended by the BLM.

EXHIBIT B
March 15, 2005
NM-108365

STIPULATIONS FOR FLPMA SITES

1. The holder shall indemnify the United States against any liability for damage to life or property arising from the occupancy or use of public lands under this right-of-way.

2. The holder shall comply with all applicable Federal laws and regulations existing or hereafter enacted or promulgated. In any event, the holder shall comply with the Toxic Substances Control Act of 1976, as amended (15 U.S.C. 2601, *et. seq.*) with regard to any toxic substances that are used, generated by or stored on the right-of-way or on facilities authorized by this grant. (See 40 CFR, Part 702-799 and especially, provisions on polychlorinated biphenyls, 40 CFR 761.1-761.193.) Additionally, any release of toxic substances (leaks, spills, *etc.*) in excess of the reportable quantity established by 40 CFR, Part 117 shall be reported as required by the Comprehensive Environmental Response, Compensation and Liability Act, Section 102b. A copy of any report required or requested by any Federal agency or State government as a result of a reportable release or spill of any toxic substances shall be furnished to the Authorized Officer concurrent with the filing of the reports to the involved Federal agency or State government.

3. The holder agrees to indemnify the United States against any liability arising from the release of any hazardous substance or hazardous waste (as these terms are defined in the Comprehensive Environmental Response, Compensation and Liability Act of 1980, 42 U.S.C. 9601, *et. seq.* or the Resource Conservation and Recovery Act, 42 U.S.C. 6901, *et. seq.*) on the right-of-way (unless the release or threatened release is wholly unrelated to the right-of-way holder's activity on the right-of-way). This agreement applies without regard to whether a release is caused by the holder, its agent, or unrelated third parties.

4. If, during any phase of the construction, operation, maintenance, or termination of the site any pollutant should be discharged from site facilities, or from containers, or vehicles impacting public lands, the control and total removal, disposal, and cleanup of such pollutant, wherever found, shall be the responsibility of the holder, regardless of fault. Upon failure of the holder to control, dispose of, or clean up such discharge on or affecting public lands, or to repair all damages to public lands resulting therefrom, the Authorized Officer may take such measures as deemed necessary to control and cleanup the discharge and restore the area, including, where appropriate, the aquatic environment and fish and wildlife habitats, at the full expense of the holder. Such action by the Authorized Officer shall not relieve the holder of any liability or responsibility.

5. Sites shall be maintained in an orderly, sanitary condition at all times. Waste materials, both liquid and solid, shall be disposed of promptly at an appropriate, authorized waste disposal facility in accordance with all applicable State and Federal laws. "Waste" means all discarded matter including, but not limited to, human waste, trash, garbage, and equipment.

6. All above-ground structures not subject to safety requirements shall be painted by the holder to blend with the natural color of the landscape. The paint used shall be a color which simulates "Standard Environmental Colors" designated by the Rocky Mountain Five-State Interagency Committee. The color selected for this project is Shale Green, Munsell Soil Color Chart Number 5Y 4/2.

7. The holder shall post a sign designating the BLM serial number assigned to this right-of-way grant in a permanent, conspicuous location on the site where the sign will be visible from the entry to the site. This sign will be maintained in a legible condition for the term of the right-of-way.

8. Any cultural and/or paleontological resource (historic or prehistoric site or object) discovered by the holder, or any person working on the holder's behalf, on public or Federal land shall be immediately reported to the Authorized Officer. The holder shall suspend all operations in the immediate area of such discovery until written authorization to proceed is issued by the Authorized Officer. An evaluation of the discovery will be made by the Authorized Officer to determine appropriate actions to prevent the loss of significant cultural or scientific values. The holder will be responsible for the cost of evaluation and any decision as to the proper mitigation measures will be made by the Authorized Officer after consulting with the holder.

9. Should the holder require a base of mineral material, a sales contract for removal of mineral material (caliche, sand, gravel, fill dirt) from an authorized pit, site, or on location must be obtained from the BLM prior to commencing construction. There are several options available for purchasing mineral material: contact the BLM office.

10. The area will be kept free of the following plant species: Malta starthistle, African rue, Scotch thistle, and saltcedar.

Special Stipulations:

The Authorized Officer will be contacted for the well pads and access road restoration instructions when the wells are ready for final abandonment procedures. At that time full restoration of the sites (150' X 150') will be addressed.

EXHIBIT C

BLM Serial No.: NM-108365
Company Reference:

Seed Mixture for LPC Sand/Shinnery Sites

The holder shall seed all disturbed areas with the seed mixture listed below. The seed mixture shall be planted in the amounts specified in pounds of pure live seed (PLS)* per acre. There shall be no primary or secondary noxious weeds in the seed mixture. Seed will be tested and the viability testing of seed will be done in accordance with State law(s) and within nine (9) months prior to purchase. Commercial seed will be either certified or registered seed. The seed container will be tagged in accordance with State law(s) and available for inspection by the authorized officer.

Seed will be planted using a drill equipped with a depth regulator to ensure proper depth of planting where drilling is possible. The seed mixture will be evenly and uniformly planted over the disturbed area (smaller/heavier seeds have a tendency to drop the bottom of the drill and are planted first). The holder shall take appropriate measures to ensure this does not occur. Where drilling is not possible, seed will be broadcast and the area shall be raked or chained to cover the seed. When broadcasting the seed, the pounds per acre are to be doubled. The seeding will be repeated until a satisfactory stand is established as determined by the authorized officer. Evaluation of growth will not be made before completion of at least one full growing season after seeding.

Species to be planted in pounds of pure live seed* per acre:

Species	lb/acre
Plains Bristlegrass	5lbs/A
Sand Bluestem	5lbs/A
Little Bluestem	3lbs/A
Big Bluestem	6lbs/A
Plains Coreopsis	2lbs/A
Sand Dropseed	1lbs/A
**Four-winged Saltbush	5lbs/A

* This can be used around well pads and other areas where caliche cannot be removed.

*Pounds of pure live seed:

Pounds of seed **x** percent purity **x** percent germination = pounds pure live seed

SENM-S-22

PRAIRIE CHICKENS

No surface use is allowed during the following time periods; unless otherwise specified, this stipulation does not apply to operation and maintenance of production facilities.

On the following lands:

T. 21 S., R. 32 E., NMPM
Sec. 7: All

T. 22 S., R. 31 E., NMPM
Sec. 14: All
Sec. 26: All

For the purpose of: Protecting Prairie Chickens:

Drilling for oil and gas, and 3-D geophysical exploration operations will not be allowed in Lesser Prairie Chicken Habitat during the period of March 15 through June 15, each year. During that period, other activities that produce noise or involve human activity, such as the maintenance of oil and gas facilities, geophysical exploration other than 3-D operations, and pipeline, road, and well pad construction, will be allowed except between 3:00 a.m. and 9:00 a.m. The 3:00 a.m. and 9:00 a.m. restriction will not apply to normal, around-the-clock operations, such as venting, flaring, or pumping, which do not require a human presence during the period. Additionally, no new drilling will be allowed within up to 200 meters of leks know at the time of permitting. Normal vehicle use on existing roads will not be restricted. Exhaust noise from pump jack engines must be muffled or otherwise controlled so as not to exceed 75 db measured at 30 feet from the source of the noise.

Bureau of Land Management
Carlsbad Field Office

SENM-S-22
December 1997

STATE ENGINEER OFFICE

WELL RECORD

Section 1. GENERAL INFORMATION

(A) Owner of well WASHINGTON TRU SOLUTIONS Owner's Well No. SNL-6

Street or Post Office Address P.O. BOX 2078

City and State CARLSBAD, NEW MEXICO 88221

Well was drilled under Permit No. C-3151 and is located in the:

a. NW ¼ SE ¼ ¼ ¼ ¼ of Section 7 Township 21S Range 32E N.M.P.M.

b. Tract No. _____ of Map No. _____ of the CARLSBAD DISTRICT

c. Lot No. _____ of Block No. _____ of the _____ Subdivision, recorded in LEA County.

d. X= _____ feet, Y= _____ feet, N.M. Coordinate System _____ Zone in the _____ Grant.

(B) Drilling Contractor WEST TEXAS WATER WELL SERVICE License No. WD1184

Address 3410 MANKINS ODESSA, TEXAS 79764

Drilling Began 7-5-05 Completed 8-2-05 Type tools MUD ROTARY Size of hole 11" in.

Elevation of land surface or _____ at well is 3643.32 ft. Total depth of well 1360 ft.

Completed well is ☐ shallow ☒ artesian. Depth to water upon completion of well _____ ft.

Section 2. PRINCIPAL WATER-BEARING STRATA

Depth in Feet From	Depth in Feet To	Thickness in Feet	Description of Water-Bearing Formation	Estimated Yield (gallons per minute)

Section 3. RECORD OF CASING

Diameter (inches)	Pounds per foot	Threads per in.	Depth in Feet Top	Depth in Feet Bottom	Length (feet)	Type of Shoe	Perforations From	Perforations To
12-3/4	33.41	WELDED	0	60	60			

Section 4. RECORD OF MUDDING AND CEMENTING

Depth in Feet From	Depth in Feet To	Hole Diameter	Sacks of Mud	Cubic Feet of Cement	Method of Placement
0	60	17-1/2 12-3/4 CSG		50	TRIMMIE

Section 5. PLUGGING RECORD

Plugging Contractor WEST TEXAS WATER WELL SERVICE

Address 3410 MANKINS ODESSA, TEXAS 79764

Plugging Method TRIMMIE

Date Well Plugged 8-2-05

Plugging approved by:

MIKE STAPLETON

State Engineer Representative

No.	Depth in Feet Top	Depth in Feet Bottom	Cubic Feet of Cement
1	0	1,030	650
2			
3			
4			

FOR USE OF STATE ENGINEER ONLY

Date Received

Quad _____ FWL _____ FSL _____

File No. _____ Use _____ Location No. _____

From	To	in Feet	Color and Type of Material Encountered
0	24	24	CONSTRUCTION FILL, DUNE SAND & ALLUVIUM
24	30	6	WHITE CALICHE & CALCAREOUS SAND (MESCALERO CALICHE)
30	57	27	REDDISH-BROWN CALCAREOUS SANDSTONE (MIOCENE-PLEISTOCENE GATUNA FORMATION)
57	554	497	WEAK RED SANDSTONE & LAMINATED CLAYSTONE (TRIASSIC SANTA ROSA FORMATION)
554	1045	491	RED TO REDDISH BROWN SANDY SILTSTON, SILTY CLAYSTONE & FINE SANDSTON (PERMOTRIASSIC DEWEY LAKE FORMATION)
1045	1106	61	GRAY ANHYDRITE BEDS WITH INTERMEDIATE HALITE & REDDISH BROWN MUDSTON (FORTY-NINER MEMBER OF PERMIAN RUSTLER FORMATION)
1106	1129	23	LIGHT OLIVE GRAY GYPSIFEROUS DOLOMITE (MAGENTA DOLOMITE MEMBER OF PERMIAN RUSTLER FORMATION)
1129	1324	195	GRAY ANHYDRITE BEDS W/INTERMEDIATE GRAY TO REDDISH BROWN SILTY CLAYST(THICK HALITE & THIN POLYHALITE BEDS (TAMARISK MEMBER PERMIAN RUSTLE!
1324	1346.5	22.5	BROWN DOLOMITE W/GYPSUM NODULES, SLIGHT FRACTURING & HALITE & ANHYDRI PORE FILLINGS (CULEBRA DOLOMITE MEMBER OF THE PERMIAN RUSTLER FORM)
1346.5	1351.6	5.1	DARK GRAY LAMINATED CLAYSTONE & SILTSTONE (UPPERMOST LOS MEDANOS MEMBER OF THE PERMIAN RUSTLER FORMATION)
1351.6	1354.2	2.6	REDDISH BROWN & GRAY MUDSTONE W/INTRACLASTS (UPPER LOS MEDANOS MEMBER OF PERMIAN RUSTLER FORMATION)
1354.2	1360	5.8	CLEAR, COARSE, SLIGHTLY ARGILLACEOUS HALITE W/A THIN ANHYDRITE AT TH UPPER SURFACE (UPPER LOS MEDANOS MEMBER OF PERMIAN RUSTLER FORM)

Section 7. REMARKS AND ADDITIONAL INFORMATION

ON 7-29-05, WE RAN 1327' OF TRIMMIE & 1354' OF 5-1/2 FIBERGLASS CASING - WE COULD NOT PULL TRIMMIE SO WE PULLED CASING - WASHED OVER TRIMMIE & PULLED IT - ON 8-2-05, WE RAN TRIMMIE DOWN TO 1,030 - TAGGED FILL - PLUGGED WELL - AT A LATER DATE, WE WILL MOVE OVER AND START A NEW WELL ON SAME LOCATION.

The undersigned hereby certifies that, to the best of his knowledge and belief, the foregoing is a true and correct record of the above described hole.

Tommy Keith
Driller

INSTRUCTIONS: This form should be executed in triplicate, preferably typewritten, and submitted to the appropriate district office of the State Engineer. All sections, except Section 5, shall be answered as completely and accurately as possible when any well is drilled, repaired or deepened. When this form is used as a plugging record, only Section 1(a) and Section 5 need be completed.

Yellowjacket and surface tension. Photograph by Dennis W. Powers, July 11, 2005.

Appendix E
Archeological Clearance Report

The report from Mesa Field Services on the following three pages was converted from an original Word document to an Acrobat (pdf) file and reduced in size slightly to fit page formats. The original signed document is maintained by the land management coordinator, Washington Regulatory and Environmental Services, for the WIPP Project.

1. (For BLM Use) **BLM Report No.**	**2. (For BLM Use)** **Reviewer's Initials/Date**_____ **Accepted ( ) Rejected ( )**	**3. NMCRIS Number:** 91630
4. Type of Report: **Negative (X)** **Positive ( )**		
5. Title of Report: A Cultural Resource Survey for the SNL-6, SNL-8, and SNL-15 Well Pads		**6. Fieldwork Date(s):** February 2, 2005
Author(s): Theresa Straight		**7. Report Date:** February 2, 2005
8. Consultant Name/Address: Mesa Field Services **Direct Charge:** Theresa Straight **Field Personnel Names:** Sean Simpson **Address:** P.O. Box 3072 Carlsbad, New Mexico 88221-3072 **Phone (**505**)** 628-8885		**9. Cultural Resource Permit No.:** 153-2920-03-N **10. Consultant Report No.:** MFS-1122
11. Customer Name: Westinghouse TRU Solutions, LLC **Responsible Individual:** Ron Richardson **Address:** P.O. Box 2078 Carlsbad, NM 88221 **Phone:** (505) 234-8395		**12. Customer Project No.:** P.O. 107596

13. Land Status	**BLM**	**State**	**Private**	**Other**	**Total**
a. Area Surveyed (acres)	8.44				8.44
b. Area of Effect (acres)	1.55				1.55

14. Linear **Length** N/A **Width** N/A
Block **Length** 350 ft **Width** 350 ft (each)

15. Location (Map[s] Attached):

a. State: New Mexico

b. County: Eddy and Lea Counties

c. BLM Office: Carlsbad Field Office

d. Nearest City or Town: Loving, NM

e. Legal Description: T21S, R32E, Section 7: N½ SE¼(SNL-6)
T22S, R31E, Section 14: SE¼ SE¼, Section 13: SW¼ SW¼ (SNL-8)
T22S, R31E, Section 26: SE¼ SE¼, Section 35: NE¼ NE¼ (SNL-15)

f. Well Pad Footages: approx. 1,750 ft FSL; 1,400 ft FEL Sec. 7, T21S, R32E (SNL-6)
approx. 900 ft FSL; 100 ft FEL Sec. 14, T22S, R31E (SNL-8)
approx 50 ft FSL; 700 ft FEL Sec. 26, T22S, R31E (SNL-15)

g. USGS 7.5' Map Name(s), Date(s), and Code(s): The Divide, NM 1984 (32103-D6)
Bootleg Ridge, NM 1984 (32103-C6)

16. Project Data:

a. Records Search: **Date(s) of BLM File Review:** February 1, 2005 **Name of Reviewer(s):** Theresa Straight
Date(s) of ARMS Data Review February 1, 2005 **Name of Reviewer(s):** Theresa Straight
Findings (see Field Office requirements to determine area to be reviewed during records search): One previously recorded site, LA 30766, is within 500 ft of the SNL-6 well pad. This site was not encountered during the survey. No other sites are within 0.25 mile of any of the well locations.

b. Description of Undertaking: Westinghouse TRU Solutions plans to build three monitoring wells. They are the SNL-6, SNL-8, and SNL-15. No plat sheets were provided; however, UTM grid coordinates were given for each location. They are as follows: SNL-6 (NAD 27; Zone 13) 621250 E/ 3595385 N, SNL-8 (NAD 27, Zone 13) 618524 E/ 3583795 N, and SNL-15 (NAD 27, Zone 13) 618359 E/ 3580335 N. Each well location will be 150 ft square, yet a 350 ft square was surveyed to ensure the protection of cultural resources. The project totaled 8.44 acres, all of which is located on land owned and administered by the BLM-CFO.

c. Environmental Setting (NRCS soil designation; vegetative community; elevation; etc.): The project area is located east of Livingston Ridge. The terrain is relatively flat, varying from a grade of 0.8 percent to a grade of 1.4 percent. The elevation varies from 3,480 ft to 3,640 ft above mean sea level. The soils area of the Kermit-Berino and Pyote-Maljamar-Kermit associations as defined by the Soil Conservation Service of the U.S. Department of Agriculture. Local vegetation is typical of Chihuahuan Desert Scrub and includes mesquite, grasses, and yucca. Due to this vegetative cover, ground surface visibility averaged 85 percent at the time of the survey.

Climatic information was obtained from the Western Regional Climate Center online database for the Waste Isolation Pilot Plant (WIPP). From 1986 to 2002 WIPP received an average annual precipitation of 12.68 inches. July through September were the wettest months while January through March were the driest. WIPP has an average annual high temperature of 80.1 degrees Fahrenheit and an average annual low temperature of 48.9 degrees (F). July is the warmest month with an average high of 98.0 degrees (F) and December is the coldest month with an average high of 60.0 degrees (F).

d. Field Methods (transect intervals; crew size; time in field; etc.): A crew of one spent 4 hours surveying the project area. A 15 m wide transect interval was used.

e. Artifacts Collected?: None

17. Cultural Resource Findings: No cultural material was encountered during the survey.

a. Location/Identification of Each Resource: N/A

b. Evaluation of Significance of Each Resource: N/A

18. Management Summary (Recommendations): Because no cultural material was encountered, archaeological clearance is recommended for the project as staked. If any cultural material is encountered during construction activities, work at that location should stop and archaeologists with the BLM-CFO should be notified.

19.

I certify the information provided above is correct and accurate and meets all applicable BLM standards.

Responsible Archaeologist_____ _____
Signature **Date**

THE ABOVE COMPLETES A NEGATIVE REPORT. IF ELIGIBLE OR POTENTIALLY ELIGIBLE PROPERTIES ARE INVOLEVED, THE ABOVE WILL BE THE TITLE PAGE AND ABSTRACT FOR A COMPLETE REPORT.

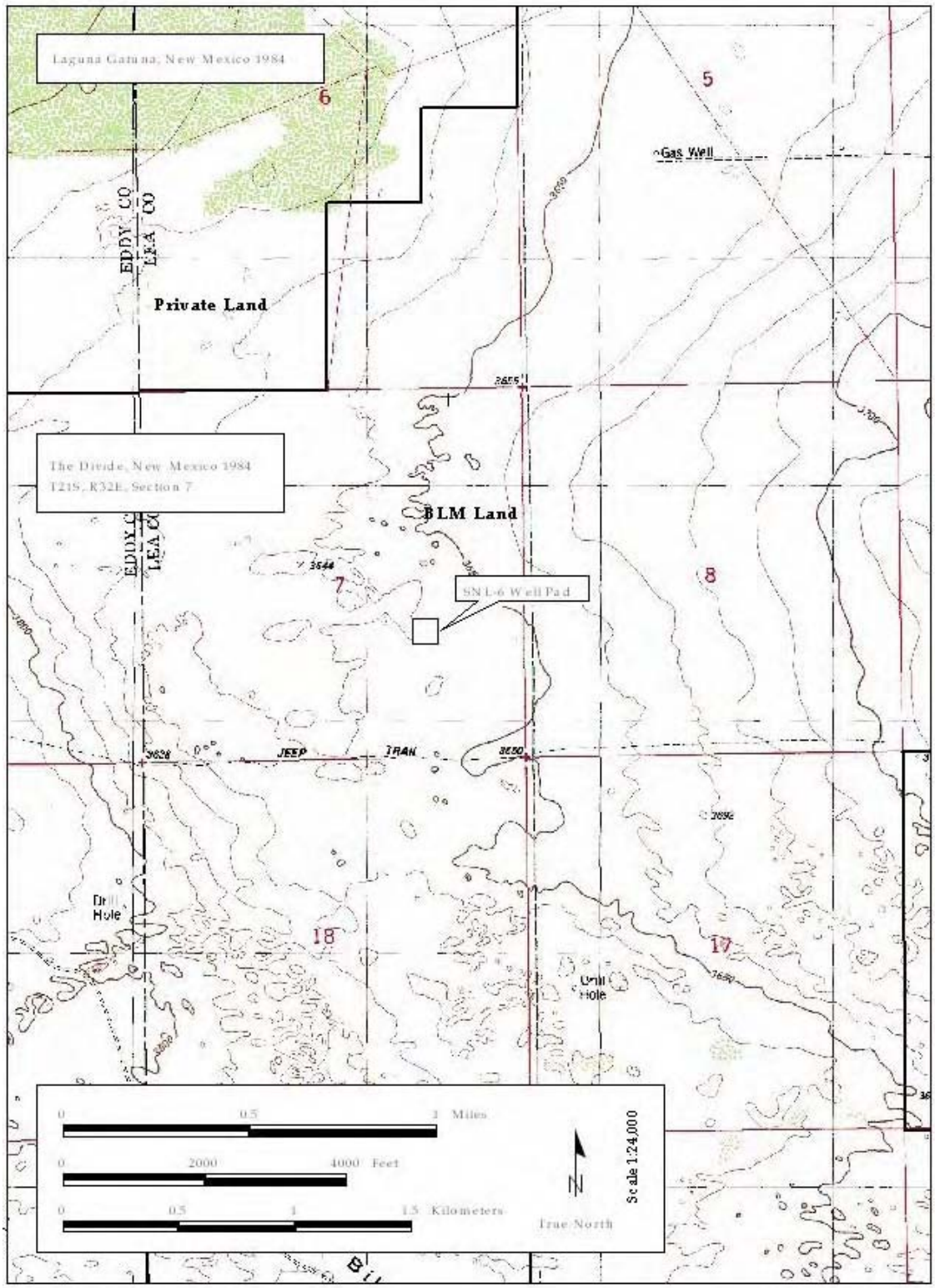


Figure 1. Project Area Map *Mesa Field Services*

Appendix F
Photograph Logs

Digital photographs were taken of the cores from SNL-6A. These photographs have been compiled into a listing of consecutive photos beginning with the uppermost core (Forty-niner Member of the Rustler Formation) and ending with the lowermost (upper Los Medaños Member of the Rustler Formation). The photographs were taken in the field shortly after recovery. A CD-ROM with these images (jpeg format) is being archived, and a copy with photographic log is maintained by Geotechnical Engineering (Washington TRU Solutions LLC) with records of the cores stored for WIPP.

No cores were taken from SNL-6, the replacement well after SNL-6A was plugged and abandoned. Note that all core boxes preserving these cores will be marked “SNL-6.”

File	DATE	LOCATION	DESCRIPTION OF SUBJECT (includes individual/group names, direction, etc. as appropriate)	PHOTOGRAPHER (initials and dept.)
SNL-6A_Core001.jpg	7/15/05	SNL-6 drillpad; T21S, R32E, sec 7	Close-up photo of Forty-niner Mbr core, 1070.0 - 1071.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-6A_Core002.jpg	7/15/05	SNL-6 drillpad; T21S, R32E, sec 7	Close-up photo of Forty-niner Mbr core, 1071.0 - 1072.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-6A_Core003.jpg	7/15/05	SNL-6 drillpad; T21S, R32E, sec 7	Close-up photo of Forty-niner Mbr core, 1072.0 - 1073.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-6A_Core004.jpg	7/15/05	SNL-6 drillpad; T21S, R32E, sec 7	Close-up photo of Forty-niner Mbr core, 1072.9 - 1074.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-6A_Core005.jpg	7/15/05	SNL-6 drillpad; T21S, R32E, sec 7	Close-up photo of Forty-niner Mbr core, 1074.0 - 1075.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-6A_Core006.jpg	7/15/05	SNL-6 drillpad; T21S, R32E, sec 7	Close-up photo of Forty-niner Mbr core, 1074.9 - 1076.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-6A_Core007.jpg	7/15/05	SNL-6 drillpad; T21S, R32E, sec 7	Close-up photo of Forty-niner Mbr core, 1076.0 - 1077.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-6A_Core008.jpg	7/15/05	SNL-6 drillpad; T21S, R32E, sec 7	Close-up photo of Forty-niner Mbr core, 1076.9 - 1078.0 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-6A_Core009.jpg	7/15/05	SNL-6 drillpad; T21S, R32E, sec 7	Close-up photo of Forty-niner Mbr core, 1083.4 - 1084.2 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-6A_Core010.jpg	7/15/05	SNL-6 drillpad; T21S, R32E, sec 7	Close-up photo of Forty-niner Mbr core, 1083.9 - 1085.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-6A_Core011.jpg	7/15/05	SNL-6 drillpad; T21S, R32E, sec 7	Close-up photo of Forty-niner Mbr core, 1085.0 - 1086.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-6A_Core012.jpg	7/15/05	SNL-6 drillpad; T21S, R32E, sec 7	Close-up photo of Forty-niner Mbr core, 1085.9 - 1087.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-6A_Core013.jpg	7/15/05	SNL-6 drillpad; T21S, R32E, sec 7	Close-up photo of Forty-niner Mbr core, 1086.9 - 1088.0 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-6A_Core014.jpg	7/15/05	SNL-6 drillpad; T21S, R32E, sec 7	Close-up photo of Forty-niner Mbr core, 1087.9 - 1089.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-6A_Core015.jpg	7/15/05	SNL-6 drillpad; T21S, R32E, sec 7	Close-up photo of Forty-niner Mbr core, 1088.9 - 1090.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-6A_Core016.jpg	7/15/05	SNL-6 drillpad; T21S, R32E, sec 7	Close-up photo of Forty-niner Mbr core, 1089.9 - 1091.1 ft bgl, with markings, scale	DW Powers Consultant to WTS

Note that core boxes in storage at WIPP will all be marked as “SNL-6.”

Camera: Nikon CoolPix 5700 **Resolution**: 2560 x 1920 **Page** 1 of 8

File	DATE	LOCATION	DESCRIPTION OF SUBJECT (includes individual/group names, direction, etc. as appropriate)	PHOTOGRAPHER (initials and dept.)
SNL-6A_Core017.jpg	7/15/05	SNL-6 drillpad; T21S, R32E, sec 7	Close-up photo of Forty-niner Mbr core, 1090.9 - 1092.0 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-6A_Core018.jpg	7/15/05	SNL-6 drillpad; T21S, R32E, sec 7	Close-up photo of Forty-niner Mbr core, 1091.9 - 1093.0 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-6A_Core019.jpg	7/15/05	SNL-6 drillpad; T21S, R32E, sec 7	Close-up photo of Forty-niner Mbr core, 1092.9 - 1094.0 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-6A_Core020.jpg	7/15/05	SNL-6 drillpad; T21S, R32E, sec 7	Close-up photo of Forty-niner Mbr core, 1093.9 - 1095.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-6A_Core021.jpg	7/15/05	SNL-6 drillpad; T21S, R32E, sec 7	Close-up photo of Forty-niner Mbr core, 1094.9 - 1096.0 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-6A_Core022.jpg	7/15/05	SNL-6 drillpad; T21S, R32E, sec 7	Close-up photo of Forty-niner Mbr core, 1095.9 - 1097.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-6A_Core023.jpg	7/15/05	SNL-6 drillpad; T21S, R32E, sec 7	Close-up photo of Forty-niner Mbr core, 1096.9 - 1098.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-6A_Core024.jpg	7/18/05	SNL-6 drillpad; T21S, R32E, sec 7	Close-up photo of Forty-niner Mbr core, 1098.0 - 1099.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-6A_Core025.jpg	7/18/05	SNL-6 drillpad; T21S, R32E, sec 7	Close-up photo of Forty-niner Mbr core, 1098.9 - 1100.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-6A_Core026.jpg	7/18/05	SNL-6 drillpad; T21S, R32E, sec 7	Close-up photo of Forty-niner Mbr core, 1100.0 - 1101.2 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-6A_Core027.jpg	7/18/05	SNL-6 drillpad; T21S, R32E, sec 7	Close-up photo of Forty-niner Mbr core, 1100.9 - 1102.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-6A_Core028.jpg	7/18/05	SNL-6 drillpad; T21S, R32E, sec 7	Close-up photo of Forty-niner Mbr core, 1101.9 - 1103.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-6A_Core029.jpg	7/18/05	SNL-6 drillpad; T21S, R32E, sec 7	Close-up photo of Forty-niner Mbr core, 1102.9 - 1104.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-6A_Core030.jpg	7/18/05	SNL-6 drillpad; T21S, R32E, sec 7	Close-up photo of Forty-niner Mbr core, 1104.0 - 1105.2 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-6A_Core031.jpg	7/18/05	SNL-6 drillpad; T21S, R32E, sec 7	Close-up photo of Forty-niner Mbr core, 1104.9 - 1106.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-6A_Core032.jpg	7/18/05	SNL-6 drillpad; T21S, R32E, sec 7	Close-up photo of Forty-niner Mbr core, 1106.0 - 1107.2 ft bgl, with markings, scale	DW Powers Consultant to WTS

File	DATE	LOCATION	DESCRIPTION OF SUBJECT (includes individual/group names, direction, etc. as appropriate)	PHOTOGRAPHER (initials and dept.)
SNL-6A_Core033.jpg	7/18/05	SNL-6 drillpad; T21S, R32E, sec 7	Close-up photo of Forty-niner / Magenta Dolomite Mbr core, 1107.0 - 1108.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-6A_Core034.jpg	7/18/05	SNL-6 drillpad; T21S, R32E, sec 7	Close-up photo of Magenta Dolomite Mbr core, 1108.0 - 1109.2 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-6A_Core035.jpg	7/18/05	SNL-6 drillpad; T21S, R32E, sec 7	Close-up photo of Magenta Dolomite Mbr core, 1108.9 - 1110.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-6A_Core036.jpg	7/18/05	SNL-6 drillpad; T21S, R32E, sec 7	Close-up photo of Magenta Dolomite Mbr core, 1109.9 - 1111.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-6A_Core037.jpg	7/18/05	SNL-6 drillpad; T21S, R32E, sec 7	Close-up photo of Magenta Dolomite Mbr core, 1110.9 - 1112.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-6A_Core038.jpg	7/18/05	SNL-6 drillpad; T21S, R32E, sec 7	Close-up photo of Magenta Dolomite Mbr core, 1111.9 - 1113.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-6A_Core039.jpg	7/18/05	SNL-6 drillpad; T21S, R32E, sec 7	Close-up photo of Magenta Dolomite Mbr core, 1112.8 - 1114.0 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-6A_Core040.jpg	7/18/05	SNL-6 drillpad; T21S, R32E, sec 7	Close-up photo of Magenta Dolomite Mbr core, 1113.7 -1114.8 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-6A_Core041.jpg	7/18/05	SNL-6 drillpad; T21S, R32E, sec 7	Close-up photo of Magenta Dolomite Mbr core, 1114.8 - 1115.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-6A_Core042.jpg	7/18/05	SNL-6 drillpad; T21S, R32E, sec 7	Close-up photo of Magenta Dolomite Mbr core, 1114.9 - 1116.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-6A_Core043.jpg	7/18/05	SNL-6 drillpad; T21S, R32E, sec 7	Close-up photo of Magenta Dolomite Mbr core, 1115.9 - 1117.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-6A_Core044.jpg	7/18/05	SNL-6 drillpad; T21S, R32E, sec 7	Close-up photo of Magenta Dolomite Mbr core, 1117.0 - 1118.2 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-6A_Core045.jpg	7/18/05	SNL-6 drillpad; T21S, R32E, sec 7	Close-up photo of Magenta Dolomite Mbr core, 1118.0 - 1119.2 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-6A_Core046.jpg	7/18/05	SNL-6 drillpad; T21S, R32E, sec 7	Close-up photo of Magenta Dolomite Mbr core, 1118.9 - 1120.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-6A_Core047.jpg	7/18/05	SNL-6 drillpad; T21S, R32E, sec 7	Close-up photo of Magenta Dolomite Mbr core, 1120.0 - 1121.2 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-6A_Core048.jpg	7/18/05	SNL-6 drillpad; T21S, R32E, sec 7	Close-up photo of Magenta Dolomite Mbr core, 1121.0 - 1122.1 ft bgl, with markings, scale	DW Powers Consultant to WTS

File	DATE	LOCATION	DESCRIPTION OF SUBJECT (includes individual/group names, direction, etc. as appropriate)	PHOTOGRAPHER (initials and dept.)
SNL-6A_Core049.jpg	7/18/05	SNL-6 drillpad; T21S, R32E, sec 7	Close-up photo of Magenta Dolomite Mbr core, 1122.0 - 1123.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-6A_Core050.jpg	7/18/05	SNL-6 drillpad; T21S, R32E, sec 7	Close-up photo of Magenta Dolomite Mbr core, 1123.0 - 1124.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-6A_Core051.jpg	7/18/05	SNL-6 drillpad; T21S, R32E, sec 7	Close-up photo of Magenta Dolomite Mbr core, 1123.9 - 1125.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-6A_Core052.jpg	7/18/05	SNL-6 drillpad; T21S, R32E, sec 7	Close-up photo of Magenta Dolomite Mbr core, 1125.0 - 1126.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-6A_Core053.jpg	7/18/05	SNL-6 drillpad; T21S, R32E, sec 7	Close-up photo of Magenta Dolomite Mbr core, 1126.1 - 1127.2 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-6A_Core054.jpg	7/18/05	SNL-6 drillpad; T21S, R32E, sec 7	Close-up photo of Magenta Dolomite Mbr core, 1126.9 -1128.0 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-6A_Core055.jpg	7/27/05	SNL-6 drillpad; T21S, R32E, sec 7	Close-up photo of Tamarisk Mbr core, 1292.0 - 1293.0 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-6A_Core056.jpg	7/27/05	SNL-6 drillpad; T21S, R32E, sec 7	Close-up photo of Tamarisk Mbr core, 1293.0 - 1294.0 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-6A_Core057.jpg	7/27/05	SNL-6 drillpad; T21S, R32E, sec 7	Close-up photo of Tamarisk Mbr core, 1294.0 - 1295.0 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-6A_Core058.jpg	7/27/05	SNL-6 drillpad; T21S, R32E, sec 7	Close-up photo of Tamarisk Mbr core, 1295.0 - 1296.0 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-6A_Core059.jpg	7/27/05	SNL-6 drillpad; T21S, R32E, sec 7	Close-up photo of Tamarisk Mbr core, 1296.0 - 1297.0 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-6A_Core060.jpg	7/27/05	SNL-6 drillpad; T21S, R32E, sec 7	Close-up photo of Tamarisk Mbr core, 1297.0 - 1298.0 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-6A_Core061.jpg	7/27/05	SNL-6 drillpad; T21S, R32E, sec 7	Close-up photo of Tamarisk Mbr core, 1298.0 - 1299.0 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-6A_Core062.jpg	7/27/05	SNL-6 drillpad; T21S, R32E, sec 7	Close-up photo of Tamarisk Mbr core, 1299.0 - 1300.0 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-6A_Core063.jpg	7/27/05	SNL-6 drillpad; T21S, R32E, sec 7	Close-up photo of Tamarisk Mbr core, 1300.0 - 1301.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-6A_Core064.jpg	7/27/05	SNL-6 drillpad; T21S, R32E, sec 7	Close-up photo of Tamarisk Mbr core, 1300.9 - 1302.1 ft bgl, with markings, scale	DW Powers Consultant to WTS

File	DATE	LOCATION	DESCRIPTION OF SUBJECT (includes individual/group names, direction, etc. as appropriate)	PHOTOGRAPHER (initials and dept.)
SNL-6A_Core065.jpg	7/27/05	SNL-6 drillpad; T21S, R32E, sec 7	Close-up photo of Tamarisk Mbr core, 1301.9 - 1303.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-6A_Core066.jpg	7/27/05	SNL-6 drillpad; T21S, R32E, sec 7	Close-up photo of Tamarisk Mbr core, 1302.9 - 1304.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-6A_Core067.jpg	7/27/05	SNL-6 drillpad; T21S, R32E, sec 7	Close-up photo of Tamarisk Mbr core, 1304.0 - 1305.1 ft bgl, with scale	DW Powers Consultant to WTS
SNL-6A_Core068.jpg	7/27/05	SNL-6 drillpad; T21S, R32E, sec 7	Close-up photo of Tamarisk Mbr core, 1305.0 - 1306.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-6A_Core069.jpg	7/27/05	SNL-6 drillpad; T21S, R32E, sec 7	Close-up photo of Tamarisk Mbr core, 1305.9 -1307.0 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-6A_Core070.jpg	7/27/05	SNL-6 drillpad; T21S, R32E, sec 7	Close-up photo of Tamarisk Mbr core, 1307.0 - 1308.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-6A_Core071.jpg	7/27/05	SNL-6 drillpad; T21S, R32E, sec 7	Close-up photo of Tamarisk Mbr core, 1308.0 - 1308.4 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-6A_Core072.jpg	7/27/05	SNL-6 drillpad; T21S, R32E, sec 7	Close-up photo of Tamarisk Mbr core, 1308.4 - 1309.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-6A_Core073.jpg	7/27/05	SNL-6 drillpad; T21S, R32E, sec 7	Close-up photo of Tamarisk Mbr core, 1308.9 - 1310.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-6A_Core074.jpg	7/27/05	SNL-6 drillpad; T21S, R32E, sec 7	Close-up photo of Tamarisk Mbr core, 1310.0 - 1311.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-6A_Core075.jpg	7/27/05	SNL-6 drillpad; T21S, R32E, sec 7	Close-up photo of Tamarisk Mbr core, 1310.9 - 1312.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-6A_Core076.jpg	7/27/05	SNL-6 drillpad; T21S, R32E, sec 7	Close-up photo of Tamarisk Mbr core, 1311.9 - 1313.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-6A_Core077.jpg	7/27/05	SNL-6 drillpad; T21S, R32E, sec 7	Close-up photo of Tamarisk Mbr core, 1312.9 - 1314.0 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-6A_Core078.jpg	7/27/05	SNL-6 drillpad; T21S, R32E, sec 7	Close-up photo of Tamarisk Mbr core, 1313.9 - 1315.1 ft bgl, with markings, scale	DW Powers Consultant to WTS

File	DATE	LOCATION	DESCRIPTION OF SUBJECT (includes individual/group names, direction, etc. as appropriate)	PHOTOGRAPHER (initials and dept.)
SNL-6A_Core079.jpg	7/27/05	SNL-6 drillpad; T21S, R32E, sec 7	Close-up photo of Tamarisk Mbr core, 1314.9 - 1316.1.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-6A_Core080.jpg	7/27/05	SNL-6 drillpad; T21S, R32E, sec 7	Close-up photo of Tamarisk Mbr core, 1316.0 -1317.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-6A_Core081.jpg	7/27/05	SNL-6 drillpad; T21S, R32E, sec 7	Close-up photo of Tamarisk Mbr core, 1317.0 - 1318.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-6A_Core082.jpg	7/27/05	SNL-6 drillpad; T21S, R32E, sec 7	Close-up photo of Tamarisk Mbr core, 1317.9 - 1319.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-6A_Core083.jpg	7/27/05	SNL-6 drillpad; T21S, R32E, sec 7	Close-up photo of Tamarisk Mbr core, 1318.9 - 1320.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-6A_Core084.jpg	7/27/05	SNL-6 drillpad; T21S, R32E, sec 7	Close-up photo of Tamarisk Mbr core, 1319.9 - 1321.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-6A_Core085.jpg	7/27/05	SNL-6 drillpad; T21S, R32E, sec 7	Close-up photo of Tamarisk Mbr core, 1320.9 - 1322.0 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-6A_Core086.jpg	7/27/05	SNL-6 drillpad; T21S, R32E, sec 7	Close-up photo of Tamarisk Mbr core, 1322.0 - 1323.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-6A_Core087.jpg	7/27/05	SNL-6 drillpad; T21S, R32E, sec 7	Close-up photo of Tamarisk / Culebra Dolomite Mbr core, 1322.9 - 1324.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-6A_Core088.jpg	7/27/05	SNL-6 drillpad; T21S, R32E, sec 7	Close-up photo of Culebra Dolomite Mbr core, 1323.9 - 1325.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-6A_Core089.jpg	7/27/05	SNL-6 drillpad; T21S, R32E, sec 7	Close-up photo of Culebra Dolomite Mbr core, 1324.9 - 1326.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-6A_Core090.jpg	7/27/05	SNL-6 drillpad; T21S, R32E, sec 7	Close-up photo of Culebra Dolomite Mbr core, 1325.9 - 1326.3 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-6A_Core091.jpg	7/28/05	SNL-6 drillpad; T21S, R32E, sec 7	Close-up photo of Culebra Dolomite Mbr core, 1326.0 - 1327.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-6A_Core092.jpg	7/28/05	SNL-6 drillpad; T21S, R32E, sec 7	Close-up photo of Culebra Dolomite Mbr core, 1326.9 - 1328.0 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-6A_Core093.jpg	7/28/05	SNL-6 drillpad; T21S, R32E, sec 7	Close-up photo of Culebra Dolomite Mbr core, 1327.9 - 1329.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-6A_Core094.jpg	7/28/05	SNL-6 drillpad; T21S, R32E, sec 7	Close-up photo of Culebra Dolomite Mbr core, 1328.9 - 1330.1 ft bgl, with markings, scale	DW Powers Consultant to WTS

File	DATE	LOCATION	DESCRIPTION OF SUBJECT (includes individual/group names, direction, etc. as appropriate)	PHOTOGRAPHER (initials and dept.)
SNL-6A_Core095.jpg	7/28/05	SNL-6 drillpad; T21S, R32E, sec 7	Close-up photo of Culebra Dolomite Mbr core, 1329.9 - 1331.0 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-6A_Core096.jpg	7/28/05	SNL-6 drillpad; T21S, R32E, sec 7	Close-up photo of Culebra Dolomite Mbr core, 1330.8 - 1332.0 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-6A_Core097.jpg	7/28/05	SNL-6 drillpad; T21S, R32E, sec 7	Close-up photo of Culebra Dolomite Mbr core, 1331.9 - 1333.0 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-6A_Core098.jpg	7/28/05	SNL-6 drillpad; T21S, R32E, sec 7	Close-up photo of Culebra Dolomite Mbr core, 1332.9 - 1334.0 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-6A_Core099.jpg	7/28/05	SNL-6 drillpad; T21S, R32E, sec 7	Close-up photo of Culebra Dolomite Mbr core, 1333.9 - 1335.0 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-6A_Core100.jpg	7/28/05	SNL-6 drillpad; T21S, R32E, sec 7	Close-up photo of Culebra Dolomite Mbr core, 1334.8 - 1336.0 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-6A_Core101.jpg	7/28/05	SNL-6 drillpad; T21S, R32E, sec 7	Close-up photo of Culebra Dolomite Mbr core, 1335.1 - 1337.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-6A_Core102.jpg	7/28/05	SNL-6 drillpad; T21S, R32E, sec 7	Close-up photo of Culebra Dolomite Mbr core, 1336.8 - 1337.5 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-6A_Core103.jpg	7/28/05	SNL-6 drillpad; T21S, R32E, sec 7	Close-up photo of Culebra Dolomite Mbr core, 1337.1 - 1338.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-6A_Core104.jpg	7/28/05	SNL-6 drillpad; T21S, R32E, sec 7	Close-up photo of Culebra Dolomite Mbr core, 1337.9 - 1339.0 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-6A_Core105.jpg	7/28/05	SNL-6 drillpad; T21S, R32E, sec 7	Close-up photo of Culebra Dolomite Mbr core, 1338.9 - 1340.0 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-6A_Core106.jpg	7/28/05	SNL-6 drillpad; T21S, R32E, sec 7	Close-up photo of Culebra Dolomite Mbr core, 1339.9 - 1341.0 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-6A_Core107.jpg	7/28/05	SNL-6 drillpad; T21S, R32E, sec 7	Close-up photo of Culebra Dolomite Mbr core, 1340.9 - 1342.0 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-6A_Core108.jpg	7/28/05	SNL-6 drillpad; T21S, R32E, sec 7	Close-up photo of Culebra Dolomite Mbr core, 1341.9 - 1343.0 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-6A_Core109.jpg	7/28/05	SNL-6 drillpad; T21S, R32E, sec 7	Close-up photo of Culebra Dolomite Mbr core, 1343.0 - 1344.0 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-6A_Core110.jpg	7/28/05	SNL-6 drillpad; T21S, R32E, sec 7	Close-up photo of Culebra Dolomite Mbr core, 1333.9 - 1345.0 ft bgl, with markings, scale	DW Powers Consultant to WTS

File	DATE	LOCATION	DESCRIPTION OF SUBJECT (includes individual/group names, direction, etc. as appropriate)	PHOTOGRAPHER (initials and dept.)
SNL-6A_Core111.jpg	7/28/05	SNL-6 drillpad; T21S, R32E, sec 7	Close-up photo of Culebra Dolomite Mbr core, 1344.9 - 1346.0 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-6A_Core112.jpg	7/28/05	SNL-6 drillpad; T21S, R32E, sec 7	Close-up photo of Culebra Dolomite / Los Medaños Mbr core, 1345.9 - 1347.0 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-6A_Core113.jpg	7/28/05	SNL-6 drillpad; T21S, R32E, sec 7	Close-up photo of Los Medaños Mbr core, 1346.9 - 1348.0 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-6A_Core114.jpg	7/28/05	SNL-6 drillpad; T21S, R32E, sec 7	Close-up photo of Los Medaños Mbr core, 1347.9 - 1349.0 ft bgl, with scale	DW Powers Consultant to WTS
SNL-6A_Core115.jpg	7/28/05	SNL-6 drillpad; T21S, R32E, sec 7	Close-up photo of Los Medaños Mbr core, 1348.9 - 1350.0 ft bgl, with scale	DW Powers Consultant to WTS
SNL-6A_Core116.jpg	7/28/05	SNL-6 drillpad; T21S, R32E, sec 7	Close-up photo of Los Medaños Mbr core, 1349.9 - 1351.0 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-6A_Core117.jpg	7/28/05	SNL-6 drillpad; T21S, R32E, sec 7	Close-up photo of Los Medaños Mbr core, 1350.9 - 1352.0 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-6A_Core118.jpg	7/28/05	SNL-6 drillpad; T21S, R32E, sec 7	Close-up photo of Los Medaños Mbr core, 1351.9 - 1353.0 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-6A_Core119.jpg	7/28/05	SNL-6 drillpad; T21S, R32E, sec 7	Close-up photo of Los Medaños Mbr core, 1352.9 - 1354.0 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-6A_Core120.jpg	7/28/05	SNL-6 drillpad; T21S, R32E, sec 7	Close-up photo of Los Medaños Mbr core, 1353.9 - 1355.0 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-6A_Core121.jpg	7/28/05	SNL-6 drillpad; T21S, R32E, sec 7	Close-up photo of Los Medaños Mbr core, 1354.8 - 1356.0 ft bgl, with markings, scale	DW Powers Consultant to WTS

West Texas Water Well Service crew at SNL-6A. Photographs by Dennis W. Powers.

Appendix G
Geophysical Logs

Geophysical logging of SNL-6A was conducted by Jet West Geophysical Services, LLC, 2550 La Plata Highway, Farmington, NM, 87499-3522, on July 28, 2005. The operator was Al Henderson. Copies of the logs are maintained by Washington Regulatory and Environmental Services, Environmental Monitoring and Hydrology Section, for the WIPP project. A CD-ROM is being retained that includes:

1) Electronic copies of the logs produced by Jet West Geophysical Logging Services using WellCAD vs 4.0,
2) WellCAD Reader to open the electronic logs, and
3) Electronic data files in both .txt and .las formats.

The following geophysical logs were obtained:

- Caliper
- Natural gamma
- Compensated density-porosity
- Resistivity and spontaneous potential

SNL-6A had been cored to 1,357 with a bit having a 6.75-inch diameter; SNL-6A had been reamed to 11-inch diameter to 1,292 ft at the time of logging. A conductor casing had been placed to a depth of 60 ft bgl. The drillhole was filled with drilling brine with bentonite during logging.

The caliper log was intended for estimating material volume placed in the annulus between fiberglass reinforced plastic casing and the drillhole wall.

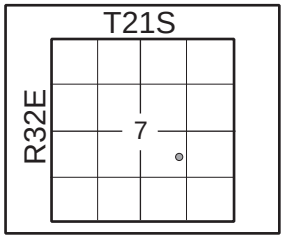
The reference point (0 ft depth) for geophysical logging was the level of the pad, which was observable relative to the surface conductor casing (see photo, next page). This point is assigned an elevation of 3,643 ft amsl based on the benchmark placed next to SNL-6A with an elevation of 3,643.42 ft. The rounded elevation of 3,643 ft amsl for the reference point is appropriate for the measurements and elevations of units for later studies.

Above: Top of surface casing (logging reference point) under rig July 27, 2005, during final coring of SNL-6A. Billy Pon (DOWDCO, yellow slicker) and Ronny Keith (WTWWS). Photo by Dennis W. Powers

Right: Marker (foreground) for SNL-6A after plugging and abandoning. SNL-6 in background behind Glen Garrett. Photo September 20, 2007.
Photo by Dennis W. Powers

Figure 2-1
Well Record SNL-6A (C-3151)

Company: Washington TRU Solutions LLC
Well: SNL-6A (C-3151)
Section: 7 Twp: T21S Rge: R32E
Location (SNL-6): 1,847 ft from south line (fsl)
1,413 ft from east line (fel)



Reference point
Log measured from: top of connector on conductor casing (gl)
Drilling measured from: gl
Permanent Datum: benchmark

Elevation
KB:
DF:
GL: 3,643 ft amsl
(benchmark: 3,643.42)

Drilling contractor: West Texas Well Water Service
Coring contractor: Diamond Oil Well Drilling Co.
Geophysical logs: Al Henderson
Jet West Geophysical Services, LLC (NM)
Geologist: Dennis W. Powers
Spud date: July 5, 2005
Plug & abandon date: August 2, 2005
Total depth (TD): 1,360 ft bgl (driller log)

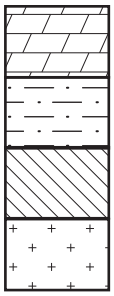
Casing Record
Conductor: 60 ft
12.75-inch o.d. steel
Casing: N/A
Screened interval: N/A
Note this casing record is for SNL-6A, not SNL-6 (not logged)

Geophysical Logs Date: July 28, 2005

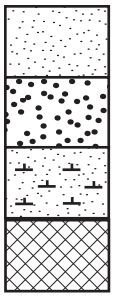
Micro/Laterolog/SP:	0-1,352 ft
Gamma/Fluid:	not obtained
Caliper:	0-1,350 ft
Density/Neutron:	0-1,356 ft

Type fluid in hole: brine with bentonite
Res mud: n/a
Res mud filtrate: n/a
Max. Rec. Temp.: not recorded

General Lithologic Symbols Used



Dolomite
Mudstone/siltstone
Anhydrite
Halite



Fine sandstone & siltstone
Coarse sandstone
Sandstone w/caliche
Polyhalite

Figure 2-1 Log Title & Header page.ai

SNL-6A Well Log Headers

Radioactive Logs
Neutron 0 1,500 counts/sec
Density 2.0 3.0 g/cc
Density Porosity 0 100 per cent

Electric Logs (ohms/m)
Spot Resistivity
R-16
R-64

feet amsl
Elevation
meters amsl
GL = 3646 ft (1111 m) amsl
Lithology
cored
feet bgs
Depth
meters bgs

Caliper 6.0 21.0 inches
Gamma 0 100 API units
SP -100 +100 mV

Stratigraphy
Member
Formation
Group
System

Drilling Fluid (Brine) in SNL-6 During Logging

Radioactive Logs
Neutron 0 — counts/sec — 1,500
Density 2.0 — g/cc — 3.0
Density Porosity 0 — per cent — 100

Electric Logs (ohms/m)
Spot Resistivity
R-16
R-64

feet amsl
Elevation
meters amsl

GL = 3646 ft (1111 m) amsl

Base Conductor Casing

Lithology
cored

feet bgs
Depth
meters bgs

Caliper 6.0 inches 21.0
Gamma 0 API units 100
SP -100 mV +100

Stratigraphy
Member
Formation
Group
System

Member	Formation	Group	System
sand	Mescalero cal.	Dockum	Triassic
	Gatuna Fm		
	(Tecovas ?)		
	(Santa Rosa ?)		
	Dewey Lake		Permian (Ochoan)
	Forty-niner	Rustler	
	agen		
	Tamarisk		
	ulebfied		