DOE/WIPP-05-3324

Basic Data Report For Drillhole SNL-8 (C-3150) (Waste Isolation Pilot Plant)

February 2009

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Basic Data Report
For Drillhole SNL-8 (C-3150)
(Waste Isolation Pilot Plant)

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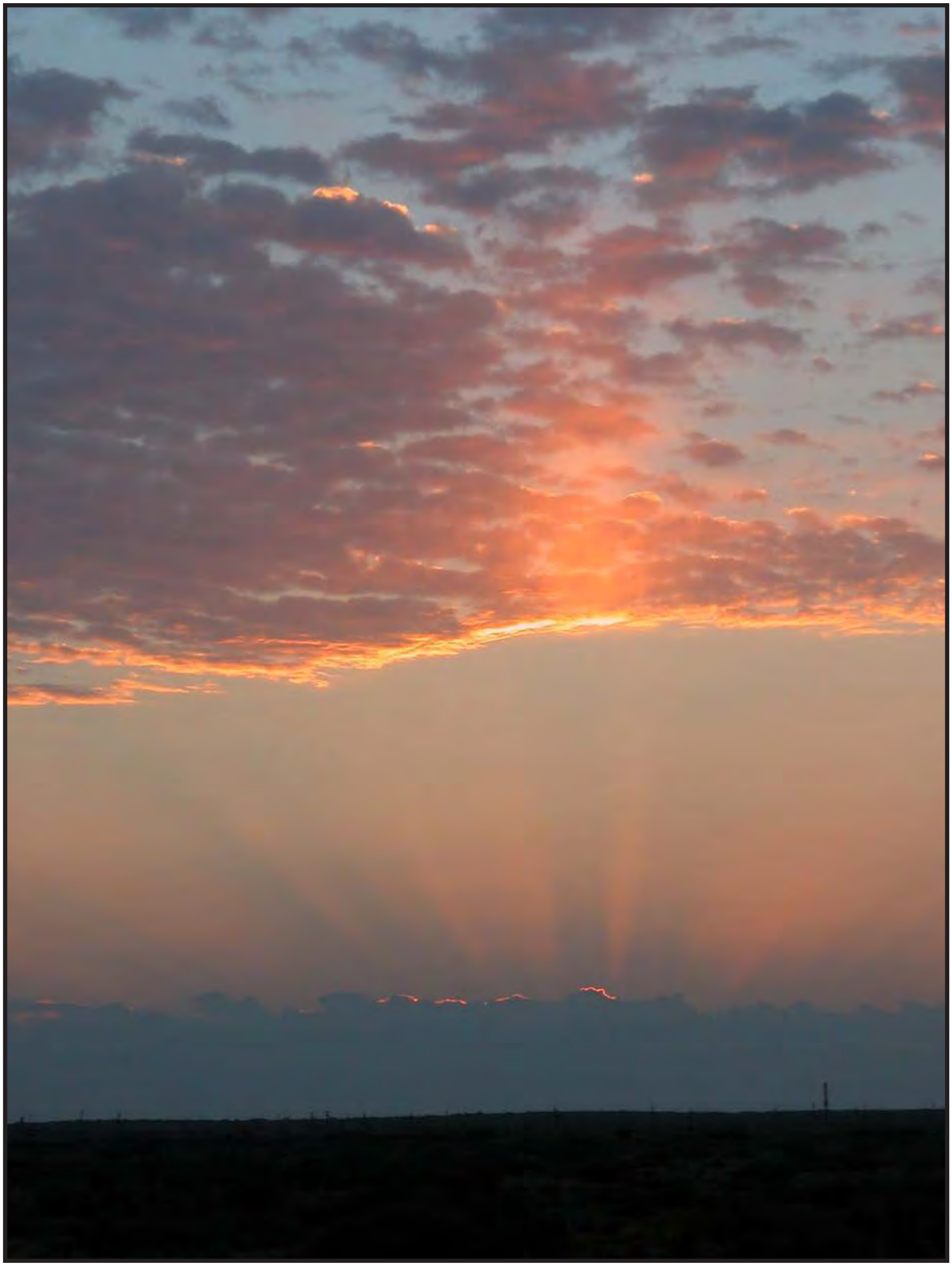
February 2009



West Texas Water Well Service Rig #15 at SNL-8 (lower right), taken from northeast access road at Waste Isolation Pilot Plant, June 16, 2005. Photo by Dennis W. Powers.

EXECUTIVE SUMMARY

SNL-8 (permitted by the New Mexico State Engineer as C-3150) was drilled and completed in June 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 Waste Isolation Pilot Plant (WIPP) site on the mudstone side of margins of M-2/H-2 and M-3/H-3 where Culebra transmissivity is expected to be low. SNL-8 is located near the southeast corner of section 14, T22S, R31E, in eastern Eddy County, New Mexico. SNL-8 was drilled to a total depth of 1,012 ft below ground level (bgl), based on driller's measurements. Below the caliche pad, SNL-8 encountered the Mescalero caliche, Gatuña, Santa Rosa, Dewey Lake, and Rustler Formations. Two intervals of the Rustler were cored: 1) from the base of the Forty-niner Member through Magenta and into uppermost Tamarisk Members and 2) from lower A-3 of the Tamarisk Member through the Culebra Dolomite and into the upper Los Medaños Member. Geophysical logs were acquired from the open hole to a depth of ~982 ft. Water flowed into the open drillhole from the lower Santa Rosa; no other water flows could be identified because of Santa Rosa inflow and because drilling continued with mist and soap while blowing Santa Rosa water.

The upper part of the Los Medaños has normal lithology, thickness, and stratigraphic sequence for areas east of WIPP. The upper part of the lower mudstone-halite unit (M-1/H-1) of the Los Medaños indicates some bedded halite. Displacive and corroded halite occur near the top of the unit. Anhydrite 1 (A-1) includes halite pseudomorphs after coarse gypsum crystals. The upper clastic-halite unit of the Los Medaños (M-2/H-2) at SNL-8 was well preserved in cores, and it is represented only by mudstone facies (M-2). The contact with the overlying Culebra was recovered. The uppermost core from M-2 is well-laminated gray silty claystone, does not indicate 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, and some are filled with gypsum. Vugs and sulfate nodules are present, but they are less abundant than in many other cores farther west. Gypsum in some fractures appears crystallographically continuous with some coarse vug-filling gypsum. Some subhorizontal bedding occurs throughout the core, and there are concentrated laminae in the the more organic-rich zone in the upper 1 ft. The Culebra is 25.8 ft thick in core. This is normal for the WIPP site. Given the limited apparent porosity and fracturing, the Culebra is expected to show low transmissivity.

The Tamarisk has a normal stratigraphic sequence for the area west of the H-3 margin. The basal sulfate (A-2) is mainly gray anhydrite that displays horizontal beds and laminae. A 0.5-ft thick laminated siltstone and claystone ~10 ft above the Culebra persists across the WIPP area. The upper surface appears eroded. At SNL-8, mudstone (M-3) of the Tamarisk shows sulfate clasts that appear rounded near the base and more angular upward. The upper Tamarisk sulfate (A-3) is 65 ft thick, consistent with other encounters in the area where H-3 is not present and sulfate beds found in H-3 to the east are part of the upper sulfate. The basal part of A-3 is fractured, with some block rotation and inter-block fill of gray claystone and siltstone. Some halite of H-3 has likely been removed at the location of SNL-8.

The Magenta Dolomite is 27.8 ft thick in core (28 ft on geophysical logs), 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 shows higher amplitude wavy bedding consistent with evidence of stromatolite forms encountered elsewhere. Small nodules occur slightly below the

top of the Magenta. Few fractures are present, and gypsum fills wider apertures. A sandier zone in the upper middle part of the Magenta appears more porous and differs in neutron count in geophysical logs. This zone occurs in many Magenta cores across the site.

The Forty-niner is represented by a sequence of sulfate–halite and mudstone–sulfate sequence. The basal anhydrite (A-4) is 17 ft thick. The short core from the base shows some gypsum as well as laminae with carbonate. M-4 is 12 ft thick, and cuttings reveal dark gray siltstone with gypsum in the lower part and reddish brown siltstone in the upper part. The upper anhydrite (A-5) of the Forty-niner is 28 ft thick, and the upper part contains gypsum. The contact with the overlying Dewey Lake appears sharp on the logs.

The Dewey Lake is thicker at SNL-8 (518 ft) than in drillholes farther west where the upper part of the formation has been eroded. The lower two general depositional sequences of the Dewey Lake are interpretable, but the upper part does not show typical decrease in natural gamma. Cuttings showed more gypsum and probable sulfate cement below 308 ft, at a location where the density log also changed. This is among the higher stratigraphic positions where this cement has been encountered in WIPP drillholes.

The Santa Rosa Formation at SNL-8 is represented by interbedded siltstones and sandstones that are multi-hued, though commonly reddish brown.

The Gatuña at SNL-8 is a thin (5 ft) calcareous sandstone, with carbonate infiltrated at the top. This location appears to be near the head of a poorly defined topographic valley leading northwest to west toward Nash Draw.

The Mescalero caliche is calcareous sand to sandy limestone at SNL-8, but cuttings were insufficient to determine the stage of development.

SNL-8 was drilled and reamed with a diameter of 11 inches. Coring (6.75-inch hole diameter) reached total depth of 1,012 ft. HolePlug® (bentonite) was placed from total depth to 991 ft, and the lower cored interval was then reamed to 995 ft for completion. Fiberglass reinforced plastic (FRP) casing (4.85 inches inside diameter) was placed in the hole, with a screen interval across the Culebra Dolomite from 952.0–978.0 ft below the top of the connector on the conductor casing. A 3-ft blank with cap was added to the bottom of the casing. Approximately 2.5 ft of FRP casing was left above the connector. Logging indicated fill to 981.5 ft. The annulus was filled with 4/10 gravel to 943 ft, above the Culebra. HolePlug® was placed from 938–943 ft to separate the Culebra from the Tamarisk mudstone. The annulus above the bentonite was cemented to the surface.

SNL-8 was completed June 28, 2005. The first water level recorded by Washington Regulatory and Environmental Services (WRES) was measured December 7, 2005; the initial depth to water was 526.59 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-8 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)

1.0 INTRODUCTION

SNL-8 was drilled near the southeast corner of section 14, T22S, R31E, in eastern Eddy County, New Mexico (Fig. 1-1). It is located 853 ft from the south line (fsl) and 116 ft from the east line (fel) of the section (Fig. 1-2). This location places the drillhole northeast of the WIPP site and on the drillpad used for P-20 (Jones, 1978), which has been plugged and abandoned. SNL-8 was begun on June 13, 2005, and was completed June 28, 2005. SNL-8 will be 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 many oil and gas wells.

SNL-8 was permitted by the New Mexico State Engineer as C-3150. 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 geology, hydrology, 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 New Mexico Environment Department. WIPP is located about 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 about 2,150 ft bgl.

1.2 Purpose of SNL-8

SNL-8 was designed and located to provide information for the integrated hydrology program for the WIPP (Sandia National Laboratories [SNL], 2003). Among the objectives of the integrated hydrology program, SNL-8 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).

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

SNL-8 was located northeast of WIPP where Culebra transmissivity is believed to be low, near the margin of halite above the Culebra (SNL, 2003). Geologic data obtained from the drillhole would help confirm the effects of Rustler halite on Culebra hydraulic properties. SNL-8 was included in the program plan (SNL, 2003), and it was co-located at the site designated WTS-8. From the program plan (SNL, 2003), SNL-8 is to:

1. Confirm the assumed low Culebra transmissivity east of the WIPP site; and

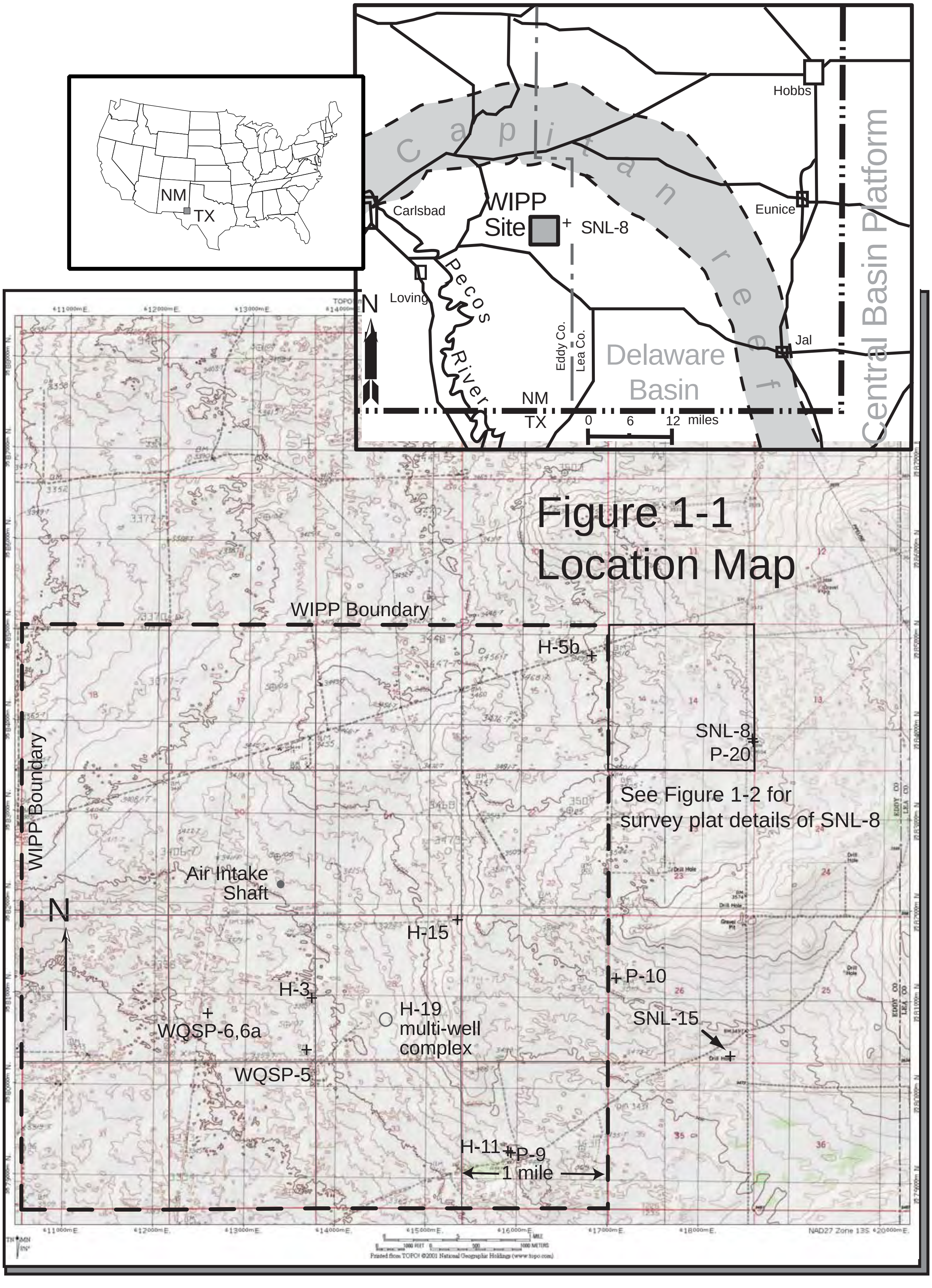


Figure 1-1
Location Map

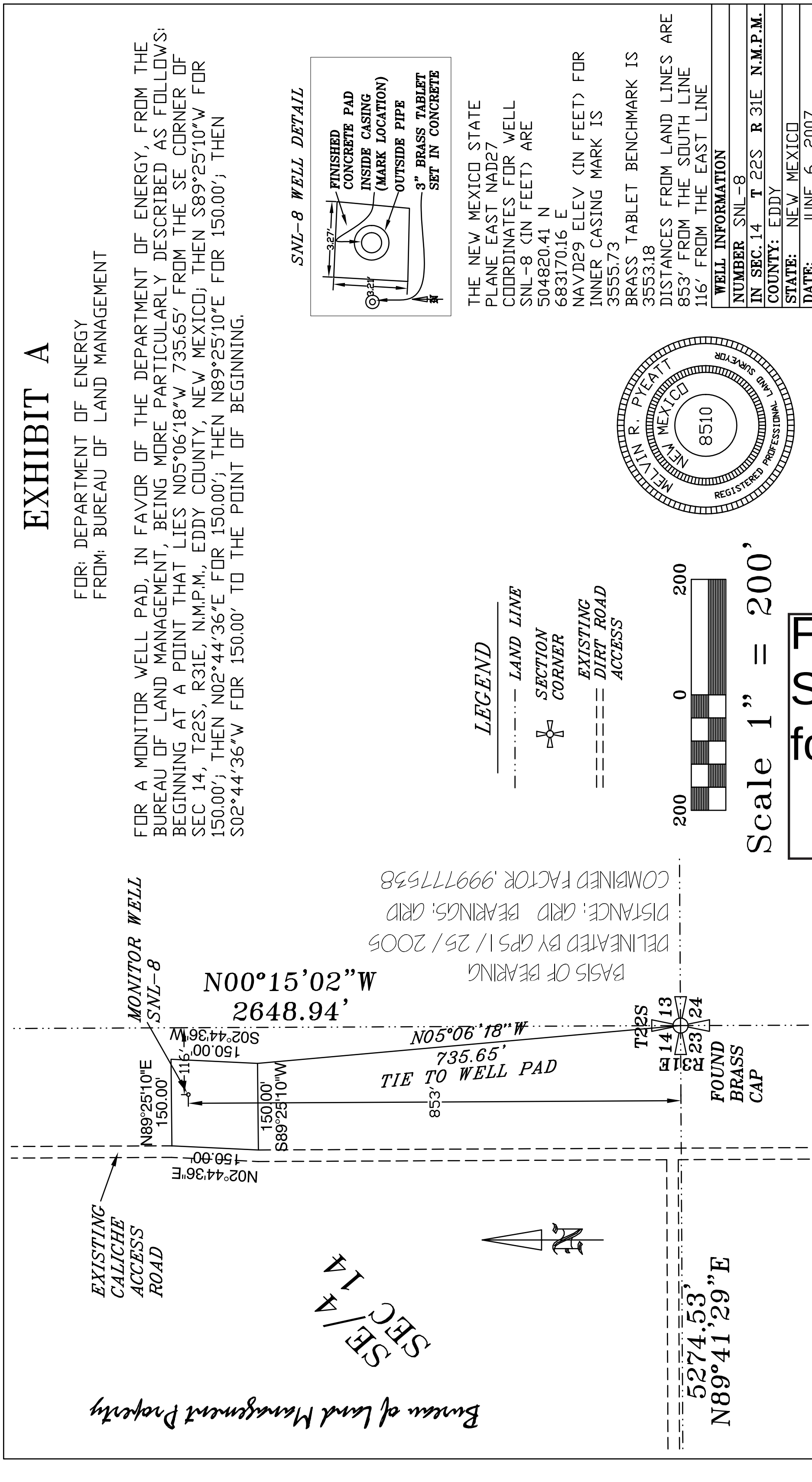


Figure 1-2
Survey Plat
for SNL-8

2. Provide information on Culebra heads in an area with many nearby oil and gas wells.

This location provides information to help define the direction and rate of groundwater flow across WIPP for reporting to the New Mexico Environment Department.

1.3 SNL-8 Drilling and Completion

The basic information about drilling and completion of SNL-8 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.

SNL-8 was rotary drilled and cored to a total depth of 1,012 ft bgl (Fig. 1-3) as measured during drilling. Coring recovery was excellent (Table 1-1), with the fitted, measured, and marked core 0.5 ft more than intervals measured during coring, despite an apparent 1 ft loss during one core run. The total depth of the drillhole as measured during drilling is 1012 ft. The bottom marked core is 1013.2 ft. For practical purposes, 1012 ft is taken as the total depth. The bottom of SNL-8 was plugged back to ~991 ft with HolePlug® before reaming the cored interval to 995 ft and logging for completion. Geophysical logging indicated the drillhole was open to 981.5 ft. SNL-8 was drilled to 255 ft using compressed air only (two compressors); compressed air with mist was used to complete drilling and coring. Cuttings from SNL-8 were of useful size because of these methods.

Core recovery was complete through the Culebra (Table 1-1; Appendix C). Complete core recovery is rare through the Culebra (e.g., Powers, 2002b; Mercer and others, 1998).

In keeping with recent practice at WIPP, SNL-8 was cased with 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).

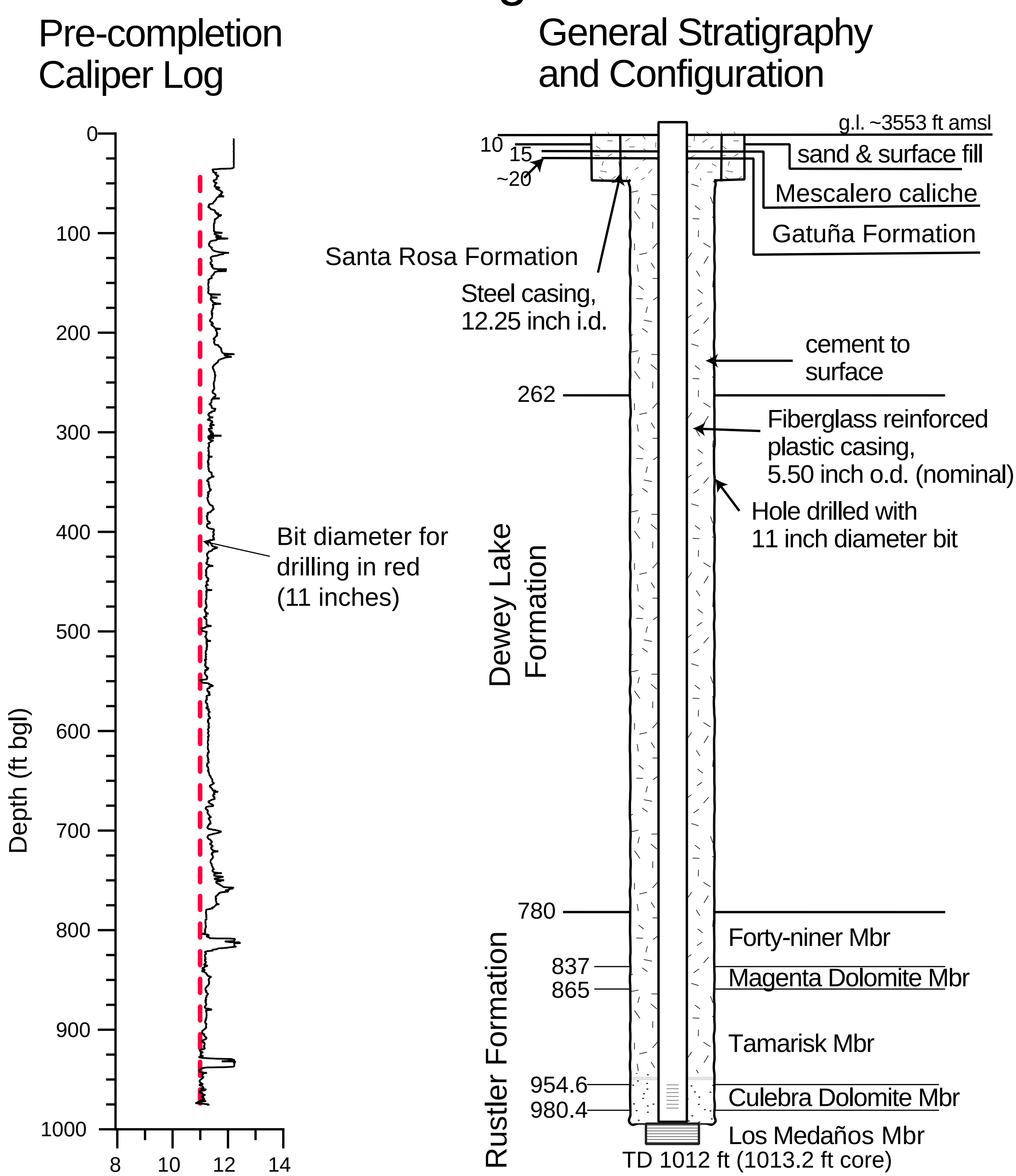
SNL-8 was completed with a single screened interval for monitoring and testing of only the Culebra Dolomite (Fig. 1-4). With a single completion interval, some of the difficulties associated with multiple completions can be avoided: expense of buying, placing, and maintaining packers; loss of water-level 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. If warranted, additional wells can be completed to other intervals, such as the Magenta Dolomite Member of the Rustler Formation, on the SNL-8 wellpad (SNL, 2003).

Geophysical logs, especially the natural gamma and caliper logs, were used to make the final decisions regarding completion of SNL-8 (Fig. 1-4) (Appendices D and E). The drillhole penetrated the uppermost part of the lower Rustler, and HolePlug® was put into SNL-8 to prevent circulation into that interval (Fig. 1-4). The bottom of the Culebra screen interval was placed at 978 ft, well above the claystone below the Culebra. The top of the screen, at 952 ft, is above the top of the Culebra. The top of the gravel pack (4/10 silica gravel) at 943 ft is below the level of the mudstone in the Tamarisk to prevent connection to the Culebra. Bentonite (HolePlug®) was placed to 938 ft, and the annulus above the bentonite was cemented to the surface. The caliper log (Fig. 1-3) after the drillhole was reamed to 995 ft at a diameter of 11 inches and before the casing was placed shows modest drillhole enlargement in the Forty-niner and Tamarisk mudstones, in the lower Dewey Lake, and throughout the Santa Rosa.

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 was cemented in place to a depth of 37 ft below the surface, with the top of the cutoff conductor casing ~6 inches

Figure 1-3
SNL-8 As-Built Diagram



SNL-8 Diameter (inches)
(after drilling to 11 inches)
See Figures 1-4 and 1-5 for
additional details

Note: Depths for drilling, geophysical logs, and completion are referenced to the top of the steel connector on the surface conductor casing, which is at the surface of the drilling pad at SNL-8 and is taken as 3,553 ft amsl.

Table 1-1. Summary of Drilling and Well Completion Records for Hydrologic Drillhole SNL-8 (C-3150)

LOCATION: Southeast ¼, Section 14, Township 22 South (T22S), Range 31 East (R31E)

SURFACE COORDINATES: The well is located 853 ft from the south line (snl) and 116 ft from the east line (fel) of Section 14. The New Mexico State Plane (NAD 27) horizontal coordinates in feet are 504820.41 North, 683170.16 East (Fig. 1-2 shows the survey plat). Universal Transverse Mercator (UTM) horizontal coordinates (NAD27, Zone 13) in meters were calculated for SNL-8 using Corpscon for Windows (v. 6): 618522.82 East, 3583783.35 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 below ground level (bgl), which is taken as 3,553 ft above mean sea level (amsl), the rounded value for the brass tablet benchmark (3,553.18 ft amsl) adjacent to the cement well pad. The primary datum for the completed well is 3,555.73 ft amsl (NGVD 29) for a mark on the top of the fiberglass reinforced plastic casing inside the protective well pipe. Figures 1-3, 1-4, and 1-5 show the as-built configuration of SNL-8.

DRILLING RECORD:

Dates: Began drilling June 13, 2005; drillhole reached total depth (1,012 ft) on June 26, 2005. Drillhole was reamed to 995 ft on June 27. Geophysical logging was conducted on June 28, 2005. SNL-8 was cased and cemented June 28, 2005. SNL-8 water level was bailed from ~500 ft below top of casing to below 950 ft below top of casing on July 7, 2005.

Circulation Fluid: SNL-8 was drilled to 255 ft bgl with circulating air. Water flowing into the hole above 255 ft resulted in using additional fresh water and Quik-Foam® to drill from 255 ft to total depth, discharging cuttings into a lined portable steel container.

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

836.0–866.0 ft bgl: basal Forty-niner, Magenta Dolomite, and uppermost Tamarisk Members

920.0–1,012.0 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-8 (C-3150), continued

Drillhole Record:

Size (inches)	From (ft bgl)	To (ft bgl)
17.5	0	37
11	37	995
6.75	995	1012

Casing Record:

Outside diameter (inches)	Inside diameter (inches)	Weight/ft (pounds)	From (ft bgl)*	To (ft bgl)
12.75	12.25	33.41 steel	-3	37
5.45	4.85	4.40 FRP** blank	-2.5	952.0
5.45	4.85	4.40 FRP screen (0.070")	952.0	978.0
5.45	4.85	4.40 FRP blank	978.0	981.0

*Top of the casing connector is ~ 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.

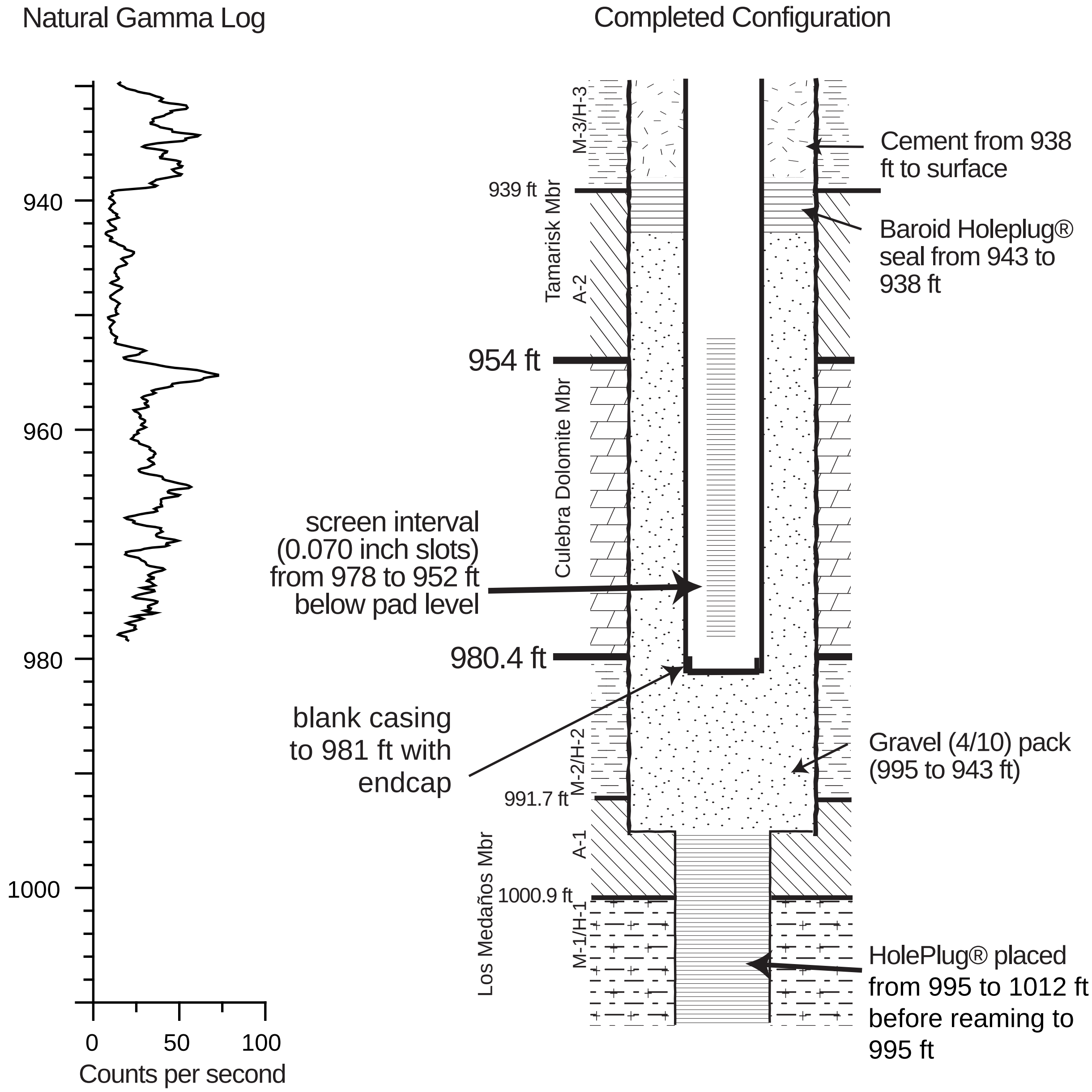
**FRP: fiberglass reinforced plastic

Coring Record:

Core Run No.	Depth Interval (ft) From	To	Interval (ft) Cored	Recovered	Recovered %
1	836	866	30	30	100.00%
2	920	935.5	15.5	14.5	93.55%
3	935.5	965.5	30	30	100.00%
4	965.5	994	28.5	28.8	101.05%
5	994	1012	18	19.2	106.67%
		Totals	122	122.5	100.41%

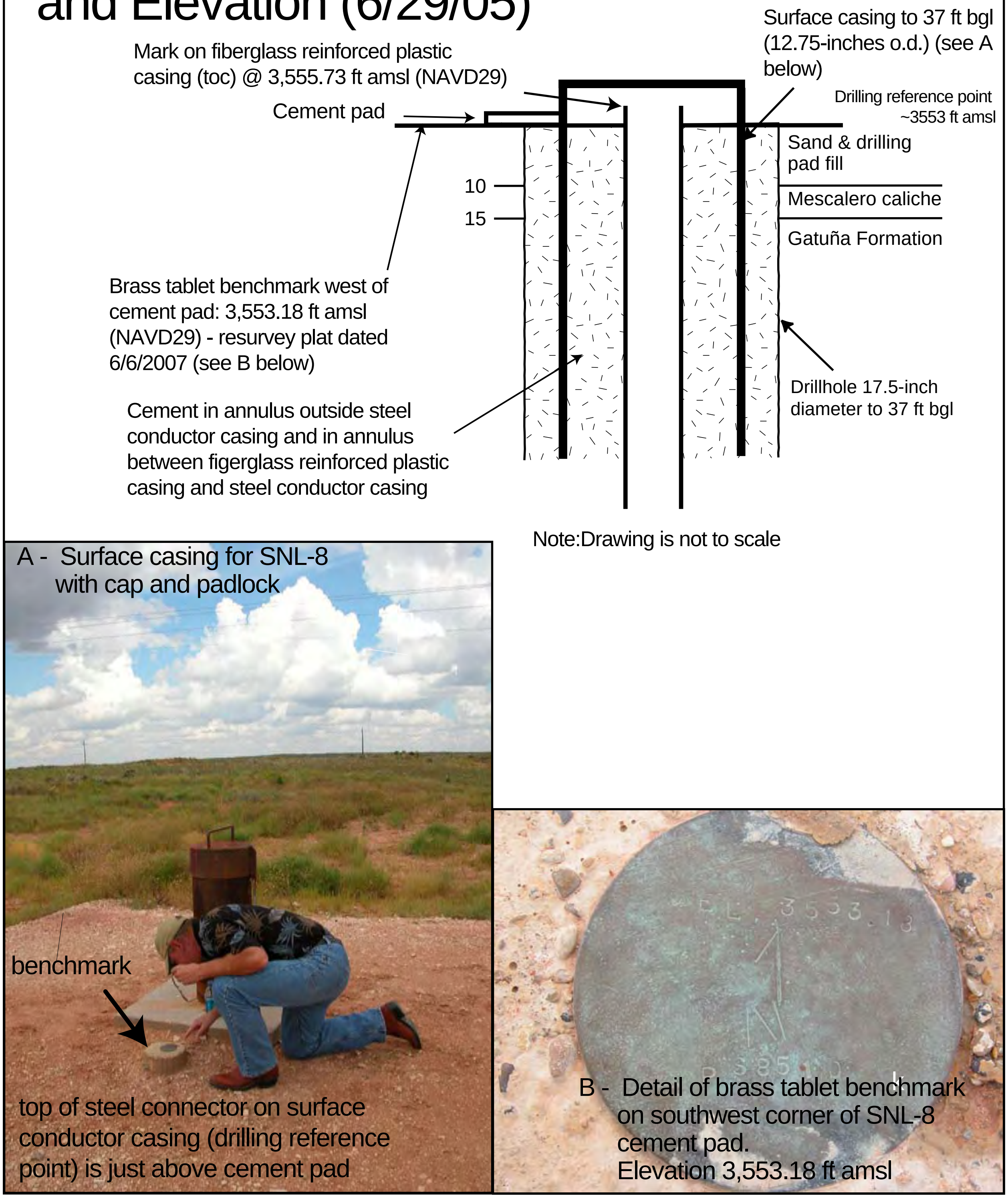
Note: The interval measured on recovered core may exceed the length measured during coring because core doesn't fit together precisely, some core from a previous run may be subsequently recovered, or depth measured during coring varies slightly.

Figure 1-4
SNL-8 Completion and Monitoring Configuration (6/28/05)



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

Figure 1-5
SNL-8 Surface Configuration and Elevation (6/29/05)



above the drilling pad level (Fig. 1-5) serving as a common reference point for drilling; geophysical logging; and placing the screened interval, sand pack, bentonite seal, and cement. The top of the steel connector was estimated to have an elevation of 3,479 ft amsl, based on a pre-drilling survey of the well pad. The benchmark placed at the drilling pad surface next to the completed well has an elevation of 3,553 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 ~3,553 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 (3,555.73 ft amsl; after resurvey, 2007) for monitoring water levels.

1.4 Other Background

SNL-8 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 W. Powers under contract to WTS. Mike Stapleton of the New Mexico Office of the State Engineer witnessed hole completion activities (Appendix D). Well drilling wastes (cuttings) were removed from SNL-8 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, New Mexico (Appendix E). Cores from SNL-8 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 Acknowledgements

Drafts of this document were reviewed by Rick Salness, Joel Siegel, 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. Ronnie 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.

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; Powers, 2002a, 2003a; Powers and others, 2003), are relevant to understanding the geology and hydrology at SNL-8.

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 Formation, 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-8

SNL-8 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 Santa Rosa during drilling in sufficient quantity to modify drilling to use mist. It was indeterminable if other units encountered below this produced water while drilling.

The geologic units encountered in SNL-8 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 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

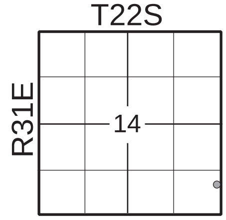
The Rustler was drilled and cored into the upper Los Medaños Member. The contact between the Rustler and the overlying Dewey Lake Formation is at 780 ft (Fig. 2-1; Table 2-1), and 233 ft of the Rustler were penetrated at SNL-8 (Table 2-1).

2.2.1.1 Los Medaños Member

The Los Medaños was named by Powers and Holt (1999) based on the rocks described in

Figure 2-1
Well Record SNL-8 (C-3150)

Company: Washington TRU Solutions LLC
Well: SNL-8 (C-3150)
Section: 14 Twp: T22S Rge: R31E
Location: 853 ft from south line (fsl)
116 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: 3553 ft amsl
(benchmark: 3553.18)

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: June 13, 2005
Completion date: June 28, 2005
Total depth (TD): 1012 ft bgl (driller log)

Casing Record
Conductor: 37 ft
12.75 inch o.d. steel
Casing: 5.45 inch o.d.
fiberglass reinforced
plastic to 981 ft bgl
Screened interval:
978-952 ft bgl

Geophysical Logs Date: June 28, 2005

Micro/Laterolog/SP:	0-981 ft
Gamma/Fluid:	0-978 ft
Caliper:	0-975 ft
Density/Neutron:	0-991 ft

Type fluid in hole: water
from drillhole to 803 ft
Res mud: n/a
Res mud filtrate: n/a
Max. Rec. Temp.:
not recorded

General Lithologic Symbols Used

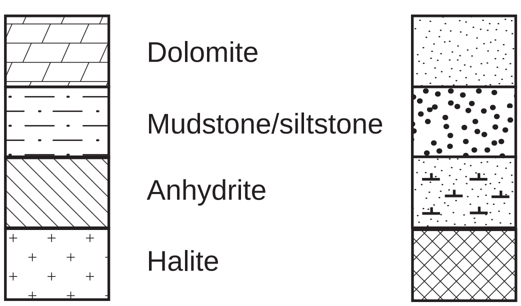
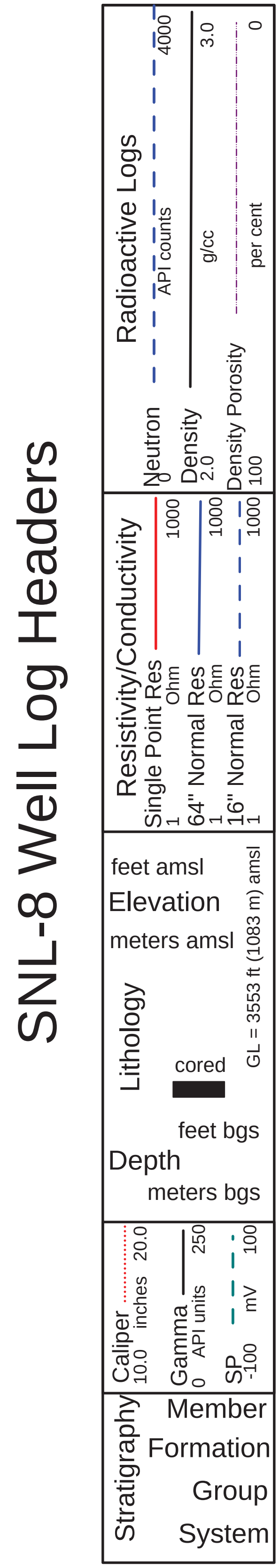


Figure 2-1 Log Title & Header page.ai



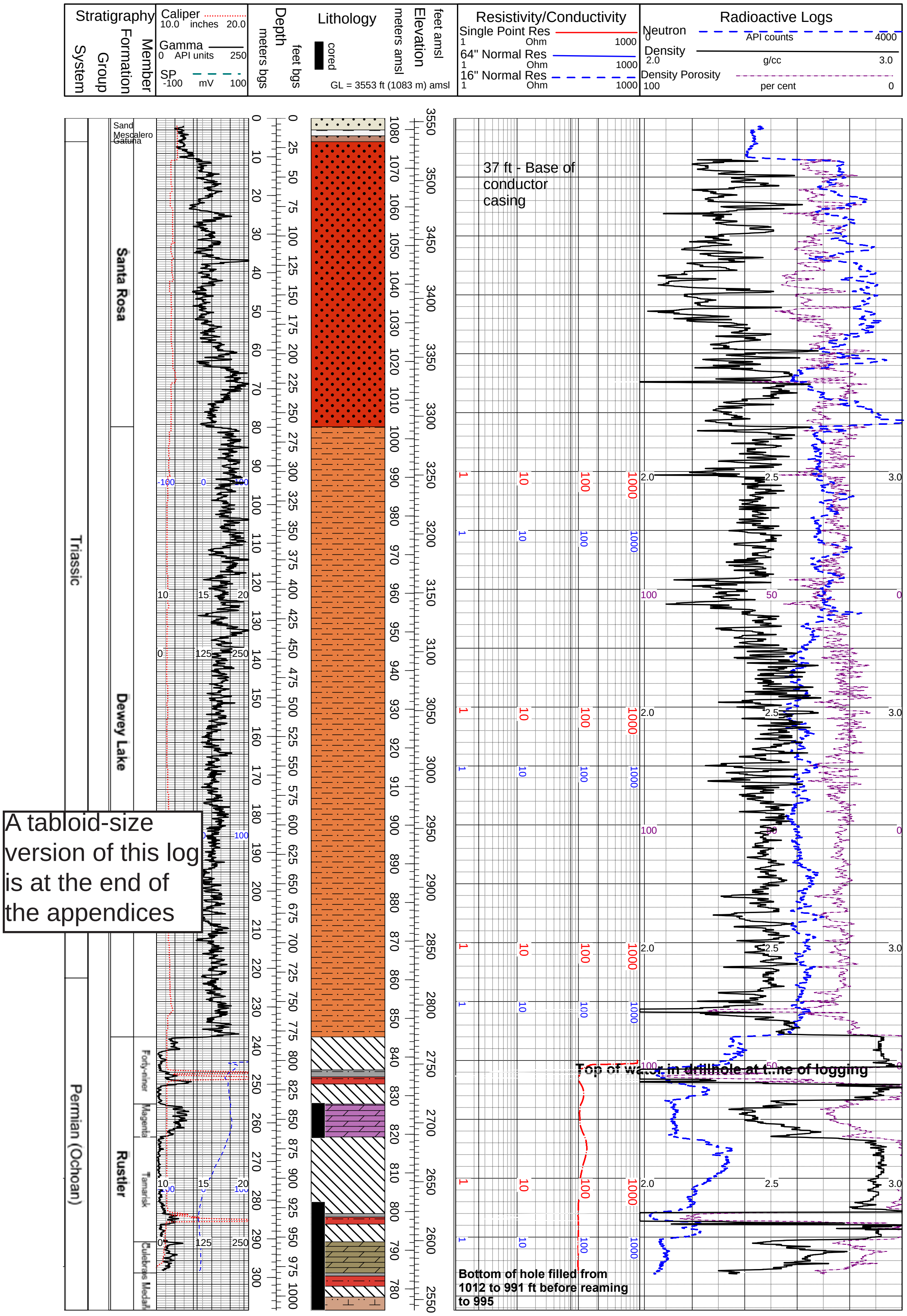

Stratigraphy
System
Group
Formation
Member
Caliper
10.0 inches 20.0
Gamma
0 API units 250
SP
-100 mV 100
Depth
meters bgs
feet bgs
Lithology
cored
Elevation
feet amsl
meters amsl
GL = 3553 ft (1083 m) amsl
Resistivity/Conductivity
Single Point Res
1 Ohm 1000
64" Normal Res
1 Ohm 1000
16" Normal Res
1 Ohm 1000
Radioactive Logs
Neutron
0 API counts 4000
Density
2.0 g/cc 3.0
Density Porosity
100 per cent 0
Triassic
Permian (Ochoan)
Sand
Mescalero
Gatuña
Santa Rosa
Dewey Lake
Rustler
Forty-niner
Magenta
Tamarisk
Culebra
Los Medaños
37 ft - Base of conductor casing
Top of water in drillhole at time of logging
Bottom of hole filled from 1012 to 991 ft before reaming to 995
A tabloid-size version of this log is at the end of the appendices

Table 2-1
Geology at Drillhole SNL-8

	System/ **Period**/Epoch	**Formation or unit**	**Member** *Informal units*	**Depth below surface (ft)**[1]
Cenozoic	Holocene	surface dune sand and pad fill		0 - 10 ft
	Pleistocene	Mescalero caliche		10 - 15 ft
	Miocene-Pleistocene	Gatuña		15 ft - ~20 ft
Mesozoic	**Triassic**	Santa Rosa[2]		~20 ft - 262 ft
		Dewey Lake[3]		262 ft - 780 ft
Paleozoic	**Permian**	Rustler	Forty-niner	780 ft - 837 ft
			A-5	*780 ft - 808 ft*
			M-4/H-4	*808 ft - 820 ft*
			A-4	*820 ft - 837 ft*
			Magenta Dolomite	837 ft - 865 ft
			Tamarisk	865 ft - 954 ft
			A-3	*865 ft - 930 ft*
			M-3/H-3	*930 ft - 939 ft*
			A-2	*939 ft - 954.6 ft*
			Culebra Dolomite	954.6 ft - 980.4 ft[1]
			Los Medaños[4]	980.4 ft - 1013.2 ft
			M-2/H-2	*980.4 ft - 991.7 ft*
			A-1	*991.7 - 1000.9 ft*
			M-1/H-1	*1000.9 - 1013.2 ft (TD)* [1]

[1]Depths are based on measurements by geophysical logging; drilling and coring provided supplemental data used from top of Culebra to total depth (TD) of 1,012 ft bgl by driller's log and 1,013.2 ft as marked on core. 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 3,553 ft amsl; it is near the elevation of the surface benchmark adjacent to SNL-8. 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 G) vary modestly from log depths.

[2]The Santa Rosa - Gatuña contact is somewhat uncertain from cuttings recovered.

[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.

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 (Fig. 2-2): 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 (Fig. 2-2), because halite below A-1 is not restricted to the thinner zone designated M-1/H-1 in these earlier publications.

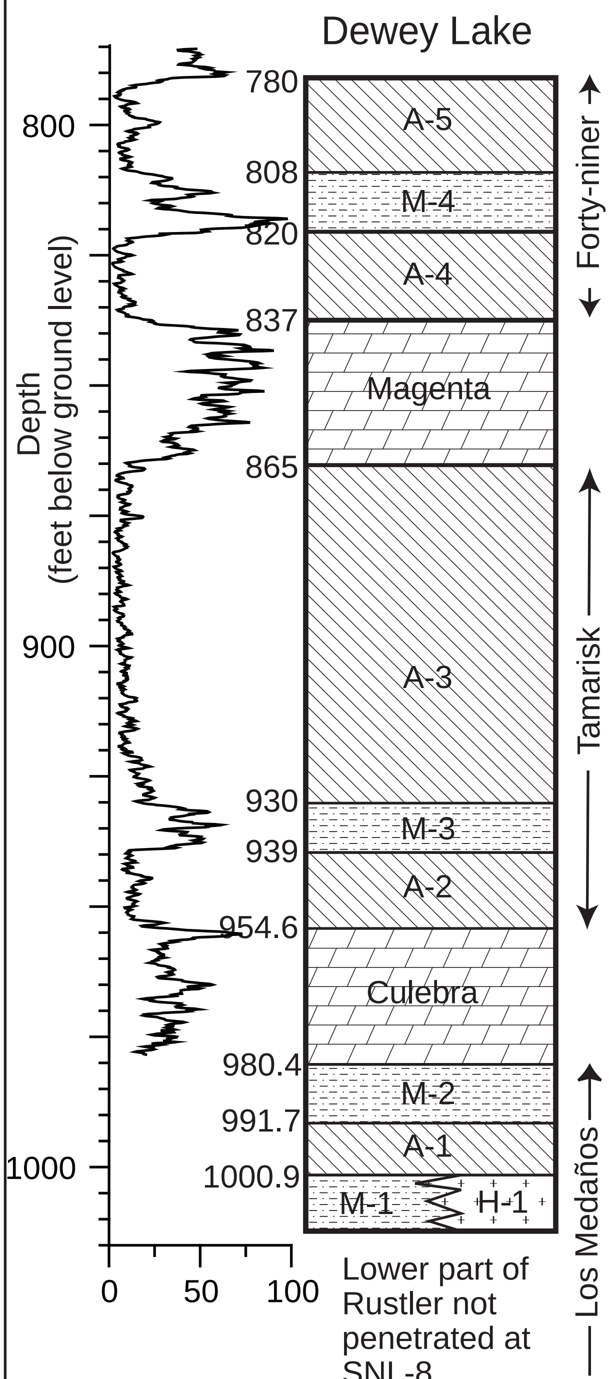
The upper part of the Los Medaños was cored (16.1 ft) in SNL-8, penetrating through M-2, A-1, and into halite facies (H-1) of M-1/H-1.

The informal unit *mudstone-halite 1* (H-1; Fig. 2-2) was encountered from 1,013.2–1,000.9 ft bgl, based on coring depths, and recovery was complete. Geophysical logs were not run on this interval, as it was filled with HolePlug® before reaming the cored interval.

The cored H-1 interval consists of halite and slightly sandy siltstone, with the siltstone ranging from horizontal beds or stringers to more dispersed siltstone blebs or boundary material around halite. The halite is generally medium to coarse and ranges from bedded to displacive. There are several crudely defined intervals or depositional cycles that display some or all of these characteristics: lower coarse halite with less siltstone and some larger fluid inclusions, increasing siltstone content upward, more displacive halite upward, more corroded halite margins upward, and more bedded and concentrated siltstone near the top (e.g., Fig. 2-3). No well-developed exposure surfaces were identified.

The informal unit *anhydrite 1* (A-1; Fig. 2-2) was encountered from 1,000.9–997.1 ft based on core data. A-1 is mainly dark to medium gray anhydrite with some gypsum. Much of A-1 is thinly

Figure 2-2
Rustler Units at SNL-8



Formal and informal Rustler Formation units and depths at SNL-8 based on natural gamma log to Culebra; core markings are used below top of Culebra.

Figure 2-3. Displacive to corroded halite at top of H-1 in SNL-8. Depth marking at 1,002.0 ft.

bedded. From the base of A-1 to ~998 ft, vertical bottom-grown gypsum is common; the gypsum generally increases in height upward, with smaller gypsum from 999.4–999 ft. Halite pseudomorphs after these gypsum crystals are also common. A thin halite interbed is present at 998.6 ft, and a stylolite occurs at 996.4 ft. Laminae in the upper part of A-1 are less distinct and somewhat wavy.

The basal contact with H-1 is narrow but not sharp.

The informal unit *mudstone-halite 2* (M-2; Fig. 2-2) was encountered from 991.7–980.4 ft bgl, based on coring depths, and recovery was complete. The natural gamma log did not go deep enough to show the contact at the top of M-2 (Fig. 2-1). The contact between M-2 and Culebra was recovered as continuous core, and the contact is sharp and undeformed (Fig. 2-4).

From 991.7–985.3 ft, the core is reddish brown (2.5YR4/4-4/6) argillaceous siltstone with indistinct horizontal bedding and possible smeared intraclast textures (Powers and Holt, 2000). The core includes some gray clasts and some dark gray clasts with fine laminae.

From 985.3–980.4 ft, the core fanges from dark gray to reddish gray (7.5YR6/0 to 2.5YR3/2) at the base to generally gray silty claystone with thin, parallel, horizontal to near horizontal thin laminae. The upper 2 ft are finer grained. Some fibrous gypsum fills bedding plane separations. Bedding is more undulatory near the base of the gray zone.

2.2.1.2 Culebra Dolomite Member

Based on drilling depths available at the time, the recovered Culebra core from SNL-8 was marked from 980.4–954.6 ft bgl (as used in information in Appendices C and F). The natural gamma log recorded only the top of Culebra, at 954 ft bgl (Fig. 2-1). Recovered Culebra core (Fig. 2-5) totals 25.8 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

Figure 2-4. Laminar silty claystone at top of M-2 in SNL-8. Depth marking at 981.0 ft.

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-8 is likely due to modest porosity with gypsum or silt fillings. Drilling using compressed air and mist may also have contributed to complete recovery.

The dolomite recovered in core from SNL-8 is generally light brownish gray (2.5Y6/2) and silty to sandy upward. The Culebra at SNL-8 is thin bedded to laminar (Fig. 2-5). Some small, possibly open vugs were observed, but it is not known if the fillings were removed during drilling. Vugs vary in size, ranging to ~2 inches, and are distributed through the unit. Larger vugs filled with gypsum are spaced out rather than being locally concentrated.

Near-vertical fractures occur mainly between ~968 and 963 ft, and they are unfilled (Fig. 2-7). Some fractures are nearly orthogonal, with block width ~2-3 inches. These fractures become less regular and less frequent upward upward to ~959 ft. A few narrow, near-vertical, curved fractures occur near the base of the Culebra.

The hydrostratigraphic units proposed for the Culebra by Holt (1997) are reasonably represented in SNL-8.

The most likely equivalent to the basal CU-4 hydrostratigraphic unit occurs from 977–980.4 ft. It has bedding, is fine-grained, light brownish gray (2.5Y6/2) and exhibits limited filled pores. Some near-vertical short fractures with curved planes are present. The basal contact is little deformed. In the WIPP site area, including H-19, this zone shows some fracturing, and the basal contact is usually slightly deformed by fracturing.

From 968–977 ft, the Culebra shows thin laminar zones and bedding at 0.5–3 inches. Small pores (~0.06–0.25 inch) are abundant, and they are partially filled with dolomite silt. Larger pores or vugs, filled with gypsum or silt occur between 970–975 ft, while some larger open vugs occur above 970 ft. The interval includes a few

Figure 2-5 Culebra Dolomite Member of the Rustler Formation at SNL-8

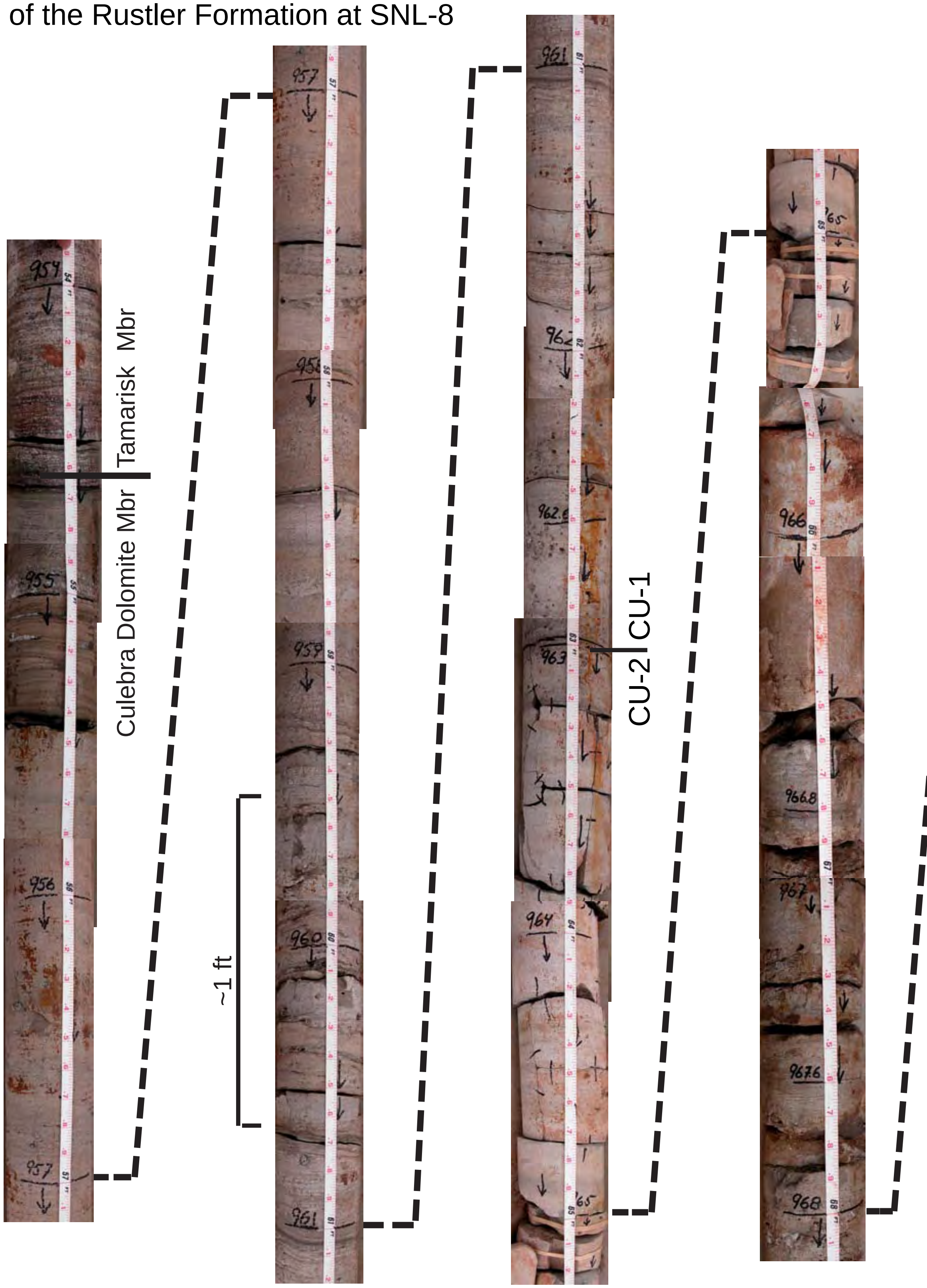
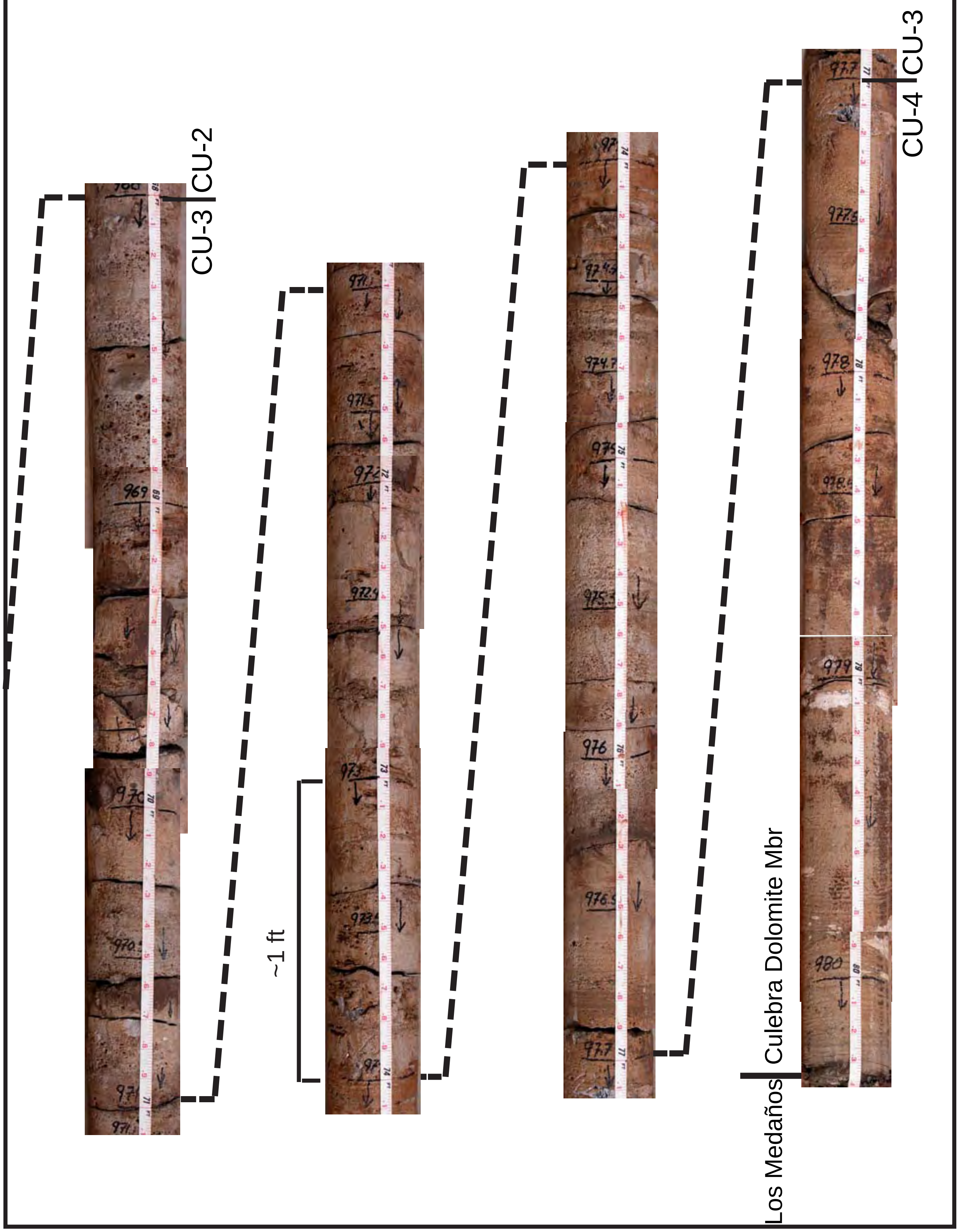


Figure 2-5 continued



high-angle fractures over vertical intervals up to 1 ft that are narrow; some have clear gypsum fillings.Bedding plane separations with dark stain are spaced 2–8 inches. A silt zone is present from 970–970.1 ft. The interval from 968–977 ft is tentatively correlated with CU-3 (Holt, 1997).

From 963–968 ft, the dolomite displays more laminar bedding, and a few, larger sulfate-filled vugs. Vertical fractures without fill and approximately orthogonal create blocks 2–3 inches wide. The entire interval is tentatively assigned to CU-2 (Holt, 1997).

From 954.6–963 ft, the dolomite is fine-grained, sandy, thin bedded to laminar, with organic-rich laminae that are slightly undulatory in the upper part. Scattered vugs to 0.5 inch are filled with gypsum. A few sub-vertical narrow fractures connect vugs. This interval tentatively corresponds to CU-1 (Holt, 1997).

The geophysical logs (Fig. 2-1) of the Culebra provide a few additional details of the unit. Resistivity remains generally low through the Culebra and overlying units into the upper anhydrite of the Tamarisk. Neutron and density logs show similar patterns: lower values in the lower and upper part of the formation with some increase corresponding approximately to CU-2. The core observations of vugs and gypsum are generally consistent with log properties. Overall, there is not a great contrast in log properties through the Culebra, and the Culebra is not likely to have either high porosity or high transmissivity based on log and core observations.

2.2.1.3 Tamarisk Member

The natural gamma log of SNL-8 shows that the Tamarisk occurs from 865–954.6 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-8 is located mainly in the M-3 facies (mudflats or saline mudflats) of these beds. The basal 10 ft of A-3 was cored in addition to all of M-3 and 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 15 ft thick (939–954 ft) based on the geophysical logs (15.5 ft based on marked core depths of 939.1–954.6 ft). The cored interval from 945.0–954.6 ft is predominantly medium gray anhydrite. It is generally fine to medium grained, with prominant laminae near the base that are less pronounced upward. Interlaminated carbonate and anhydrite near the top of this interval are wavy and may be stromatolitic. Some crinkly bedding may indicate pseudomorphs of gpysum swallowtails. Some bedded-nodular texture in middle.

A-2 is divided here, as in most locations, by a gray to purplish brown siltstone and claystone from 944.5–945.0 ft. The sharp basal contact with the lower part of A-2 slightly cross-cuts bedding, indicating an erosional surface. This claystone is laminar near the base and folded mildly at the upper transition to the overlying part of A-2.

The upper part of A-2, from 939.1–944.5 ft, is also fine, medium gray anhydrite with horizontal to sub-horizontal bedding up to ~ 1 inch. At the base, the gradational transition from the claystone shows deformed to wavy bedding and fine laminae that also may indicate stromatolites. Some of the bedded anhydrite also shows nodular textures.

The informal Tamarisk unit *mudstone 3* (M-3; Fig. 2-2) at SNL-8 is 9 ft thick (930–939 ft bgl), based on the natural gamma log, and is 9.1 ft based on core markings. Halite (H-3) is not present at SNL-8.

The geophysical log (Fig. 2-1) for M-3 shows common characteristics of the mudstone facies: an increase in natural gamma with low neutron and low density.

M-3 is mainly claystone and silty claystone that is reddish brown (5YR4/4). The basal contact is sharp and may be erosional. Bedding was not clearly observable on core surfaces from M-3. Clasts of light gray (2.5Y7/0) silty sandstone up to ~ 0.5 inch diameter and larger (2–4 inch) clasts of laminar anhydrite are present. The sandstone clasts are somewhat round, and the anhydrite clasts are generally angular, except at the base of M-3. The claystone shows slickensides at ~50–60° with variable orientations. Some slickensides are near horizontal, also with variable orientations. Some larger, more planar fractures through the core are ~ 45–60° from horizontal.

The informal Tamarisk unit *anhydrite 3* (A-3; Fig. 2-2) at SNL-8 is 65 ft thick (865–930 ft bgl) based on geophysical logs and is 65.6 ft thick based on core markings (865.4–931 ft).

A-3 is represented by mainly dark to light gray anhydrite, with laminar bedding (probably including dolomite) near the base and some gypsum and laminar dolomite near the top.

Basal A-3 was cored and shows fracturing, with bedding dipping variably. Some breaks are subparallel to bedding. Gray claystone or siltstone fills most fractures, although some are too narrow to show fill. Fracturing differs in zones, with 930–931 ft dipping up to 75°. From 928–930 ft, bedding is ~ horizontal. The most fractured and brecciated zone is 927–928 ft. In the upper part of the cored zone, maximum dips are ~ 45°, as fracturing and rotation appear to be decreasing (Fig. 2-6).

The uppermost A-3 shows some nodules developed along bedding as well as laminar bedding of carbonate that may be initial stages of algal growth that appears in the lower Magenta. The contact with the Magenta is gradational.

Figure 2-6. Fracturing with block rotation in lower A-3 at SNL-8. Core depth marking is 922 ft.

2.2.1.4 Magenta Dolomite Member

Based on geophysical logs, the Magenta at SNL-8 is 28 ft thick (837–865 ft), while core thickness is 27.8 ft (837.6-865.4 ft). This is a normal thickness for the member.

The Magenta is a gypsum and dolomite bed of light olive gray (5Y6/2) to light gray (5Y7/2) in core with some zones of olive gray (5Y5/2) where more porous. The Magenta is well bedded, showing a variety of forms from the base to top. Near the base, wavy laminae (~0.10 ft thick) with amplitudes 1 inch are stacked and are consistent with algal bedding found elsewhere in this zone. Wavy lamine are faint near the basal gradational transition from A-3 and become more pronounced upward, especially ~862.6 ft (Fig. 2-7). Amplitudes lessen upward and become ~horizontal above 860 ft. From 848.5–860 ft, laminae are nearly flat, with slight erosional bases to some sets. Some whitish starved ripples are preserved. Grains are generally silt-sized. From 841.8–848.5 ft, grain sizes increase to fine sand, and the interval appears to be the most porous and organic-rich. Laminae are emphasized by light-dark couplets. Laminae sets can be ~1 inch high. Some small ripples (0.5 inch high) have erosional bases and trough forms. From 837.6–841.8 ft, laminae are mostly horizontal, with little cross-cutting or ripples except at the basal transition from the underlying interval. An erosional surface is prominent at 839.8 ft. Grains are silt to sand sizes, and some zones include more distinct sulfate grains. Some thin (~0.5 inch) beds of mostly dolomite are present. Gypsum nodules occur in a zone from 840.7–841.8 ft, and they are larger upward.

Gypsum along bedding planes, including wavy bedding, is present from the base of the Magenta up to 859.8 ft. A few bedding planes from 846.7 ft up also display gypsum.

Three fractures from 854.1–854.7 ft, at 45°, 25°, and 80° from horizontal, are filled with gypsum. Very narrow aperture, near-vertical fractures at ~840.0 ft are apparently unfilled.

Geophysical log data from the Magenta show lower density than the adjacent anhydrite beds with the lowest density zone from 840–852 ft. This is similar to the interval of core with apparent greatest porosity. Neutron was moderate through the Magenta and did not show much zonation. Resistivity was not obtained through the Magenta, as fluid level was just below 800 ft at time of logging.

2.2.1.5 Forty-niner Member

Based on geophysical logs, the Forty-niner at SNL-8 is 57 ft thick (780–837 ft). The Forty-niner is described mainly on the basis of cuttings and geophysical logs, as only the lower 1 ft was cored. Like the Tamarisk, the Forty-niner consists of upper and lower anhydrites with a middle unit that is a mudstone at SNL-8. 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; Fig. 2-2), is gray anhydrite. A-4 is 17 ft thick (820–837 ft), based on geophysical logs. The basal core also shows mainly gray anhydrite and coarse, clear gypsum. Carbonate laminae in the cored sulfate are 0.01–0.02 ft thick.

Mudstone-halite 4 (M-4/H-4; Fig. 2-2) is about 12 ft thick (808–820 ft), based on the natural gamma and density log as well as the drilling record. Cuttings and geophysical log data indicate that only M-4 is present. The lower part of M-4 is a dark gray (5YR4/1) siltstone with gypsum. The upper part is a reddish brown sandy siltstone.

The upper sulfate unit, *anhydrite 5* (A-5), is gray (5YR6/1) fine anhydrite that is 28 ft thick (780–808 ft bgl) at SNL-8 based on geophysical logs. Drilling rates changed at ~779 ft bgl. The upper contact with the Dewey Lake Formation appears to be sharp.

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.

At SNL-8, the Dewey Lake is 518 ft thick (262–780 ft bgl) and is composed mainly of reddish-brown (2.5YR4/4) to grayish brown (2.5YR5/4) 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-8. The Dewey Lake is generally moderately well indurated. It is slightly calcareous near the top but shows no evidence of carbonate deeper. Below 301 ft, Dewey Lake cuttings include gypsum, mainly represented by fibrous gypsum; the drilling rate decreased at 312 ft in response to sulfate cements below this depth. The Dewey Lake is described on the basis of cuttings, drilling rates, and geophysical log characteristics.

Geophysical logs from SNL-8 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).

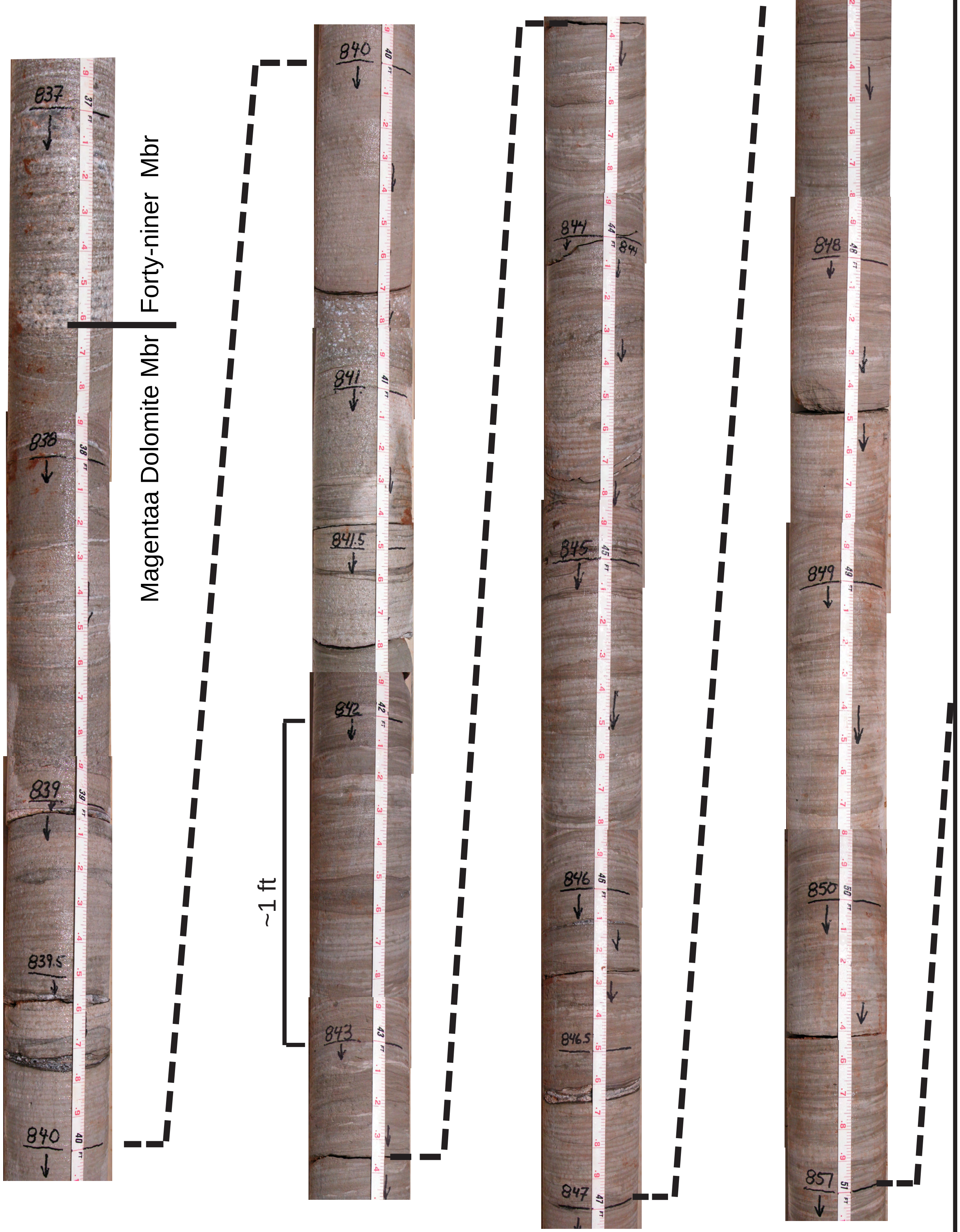
Two of three general depositional regimes for the Dewey Lake can be more readily distinguished on natural gamma logs of SNL-8; the upper regime is not distinct.

The interval from 684–784 ft bgl in SNL-8 displays the natural gamma features of the lower Dewey Lake informally called the *basal bedded zone* (Powers, 2003b). The natural gamma fluctuates around a similar value (~150–200 API units) over this vertical interval. A short low in natural gamma indicates the top of the zone. The density log shows thin lower density intervals that commonly correspond to the base of low gamma sandier intervals, and these density lows have a ~30–50 ft spacing similar to bedding in this zone.

The interval from 340–684 ft bgl (344 ft) is marked by generally upward-increasing gamma above thinner low-gamma units. The highest gamma reading is at 340 ft. These are interpreted as an interval of *fining-upward cycles* because increasing natural gamma is frequently an indicator of finer clastic grain sizes (Doveton, 1986; Powers, 2003b). The base of this interval is defined by sandstone from ~676–684 ft. Near the center of the 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 340 ft, natural gamma remains approximately the same, in contrast with decreasing natural gamma indicating coarsening upward as proposed by Powers (2003b). The contact with the Santa Rosa at 262 ft is placed where interbedded sandstones and siltstones begin to dominate.

Figure 2-7 Magenta Dolomite Member of the Rustler Formation at SNL-8



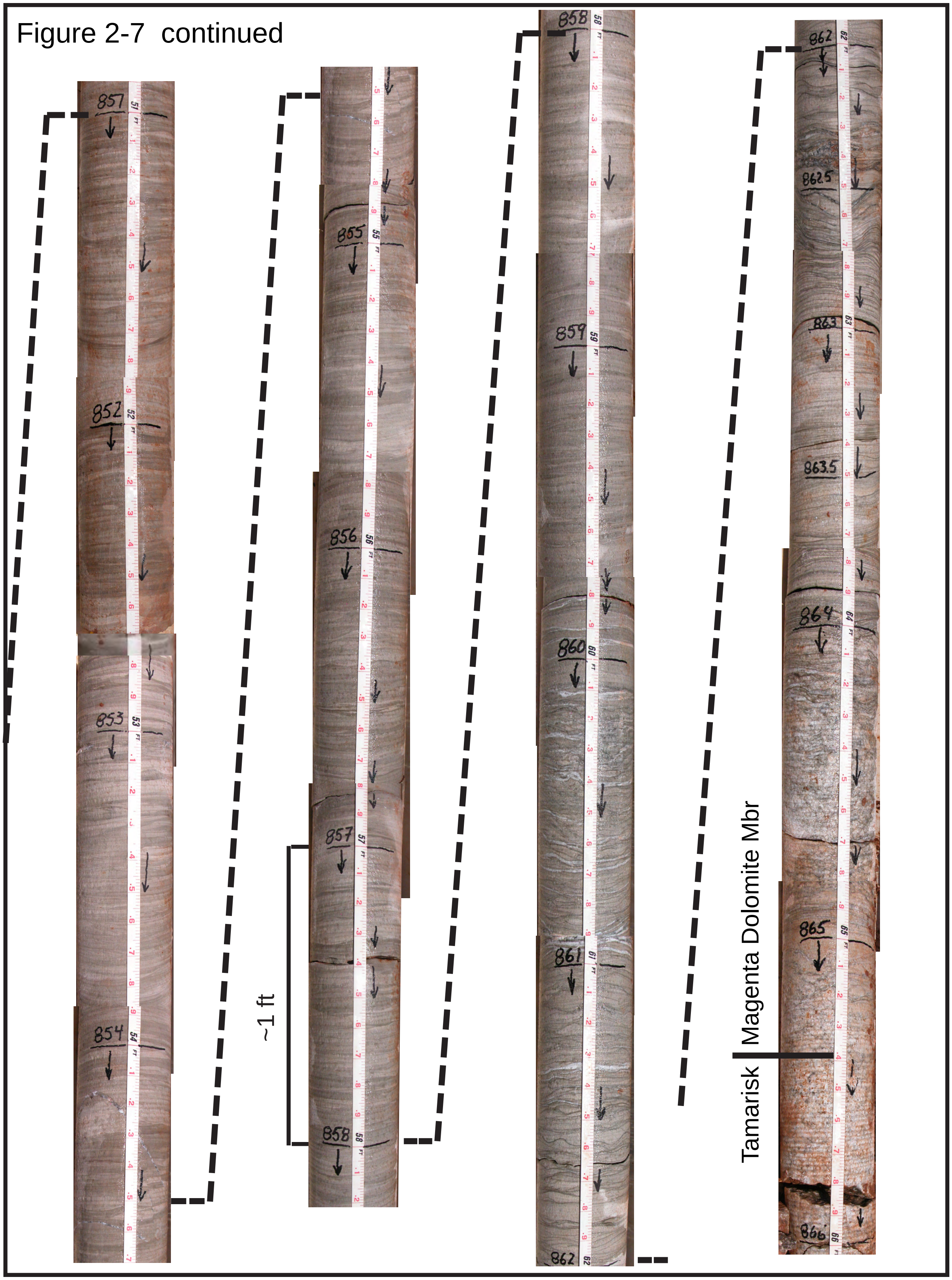


Figure 2-7 continued
~1 ft
Magenta Dolomite Mbr
Tamarisk

The natural gamma log through the fining-upward cycles shows a zone of decreased intensity over an interval from 364–374 ft, likely corresponding to one of the very fine to medium-grained sandstones found across the site area (Powers, 2003b). The sand grains in cuttings consistent with this log signature are subround to round and well cemented with sulfate. This unit likely corresponds to sandstone 1 (*ss1*), a persistent sandstone in this stratigraphic interval (Powers, 2003b).

There is a decrease in density from 280–320 ft that coincides with the absence of carbonate and first observed gypsum in cuttings. Drilling rates dropped sharply at ~312 ft, likely indicating the change to sulfate cements. The cement/density change is 468 ft above the base of the Dewey Lake and is stratigraphically higher in the Dewey Lake than at C-2737 (Powers, 2002b).

By comparison with other drillholes, the Dewey Lake is likely to be more transmissive above ~320 ft, but there were no indications of water during drilling. Water produced during drilling is thought to have come from mainly from the lower Santa Rosa Formation.

2.2.3 Triassic Santa Rosa Formation

The Santa Rosa at SNL-8 is ~242 ft thick (~20–262 ft). It is mainly interbedded siltstone and sandstone that is moderately indurated and shows a variety of colors such as weak red (2.5YR5/2) and reddish brown (2.5YR5/4, 5YR5/3) to pale brown (10YR6/3). The sandstone includes mica and coarser grains in the lower part of the formation. Sandstone also dominates above ~200 ft.

2.2.4 Miocene-Pleistocene Gatuña Formation

The Gatuña is ~5 ft thick (15–~20 ft). It is very calcareous, reddish brown sandstone.

2.2.5 Pleistocene Mescalero Caliche

The Mescalero is an informal soil stratigraphic unit defined by Bachman (1973). It is widespread in southeastern New Mexico, 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-8, the Mescalero is 5 ft thick (10–15 ft) based on shallow cuttings samples. The Mescalero is a white, very calcareous sandstone to sandy limestone. The Mescalero included clasts of Santa Rosa.

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 could not be classified at SNL-8.

2.2.6 Surficial Deposits

Construction fill and sand is up to 10 ft thick at the drillhole location. The dune sand is reddish brown, friable, and fine to medium. The Berino soil (Chugg and others, 1971) was not established at SNL-8.

3.0 PRELIMINARY HYDROLOGICAL DATA FOR SNL-8

SNL-8 was drilled specifically to monitor water levels from the Culebra Dolomite Member of the Rustler Formation and to serve as a location for observations during pumping tests.

3.1 Checks for Shallow Groundwater Above the Rustler Formation

The hole was drilled with compressed air to 255 ft. No moisture was observed in the drillhole after an overnight halt at 128 ft. Moist cuttings were encountered from 170 ft; drilling was halted overnight at 255 ft to observe water inflow.

Table 3-1 summarizes the observations at a depth of 255 ft and subsequent observations of recovery. The first five observations, including a weekend-long period, suggest the top of the potentiometric surface is in the range of 183-195 ft below ground level (in Santa Rosa) with production of a little more than 1 gallon per minute (gpm). Two of the first three observations indicate they reached an equilibrium or near-equilibrium long before the end of the observation period.

The sixth observation, with the drillhole in the lower Dewey Lake at 665 ft, shows the highest estimated rates of inflow and water level rise. It is unclear whether higher inflow rates as the hole deepened (e.g., 665 ft) reflect lack of time to reach near equilibrium or is due to additional inflow from zone(s) below 483 ft.

A sample of water blown from the drillhole on the morning of June 16, 2005, when depth was 255 ft, yielded a field observation of specific gravity of 1.0025.

A miniTroll was installed overnight on June 23, 2005, when the drillhole was at 836 ft depth, just above the Magenta Dolomite. The stable pressure increases (Fig. 3-1) through the night are linear, and the calculated production for an 11-inch diameter drillhole from the linear equation is 1.16 gpm, without accounting for specific gravity.

Table 3-1
Water Level Measurements in SNL-8 above Rustler Formation*

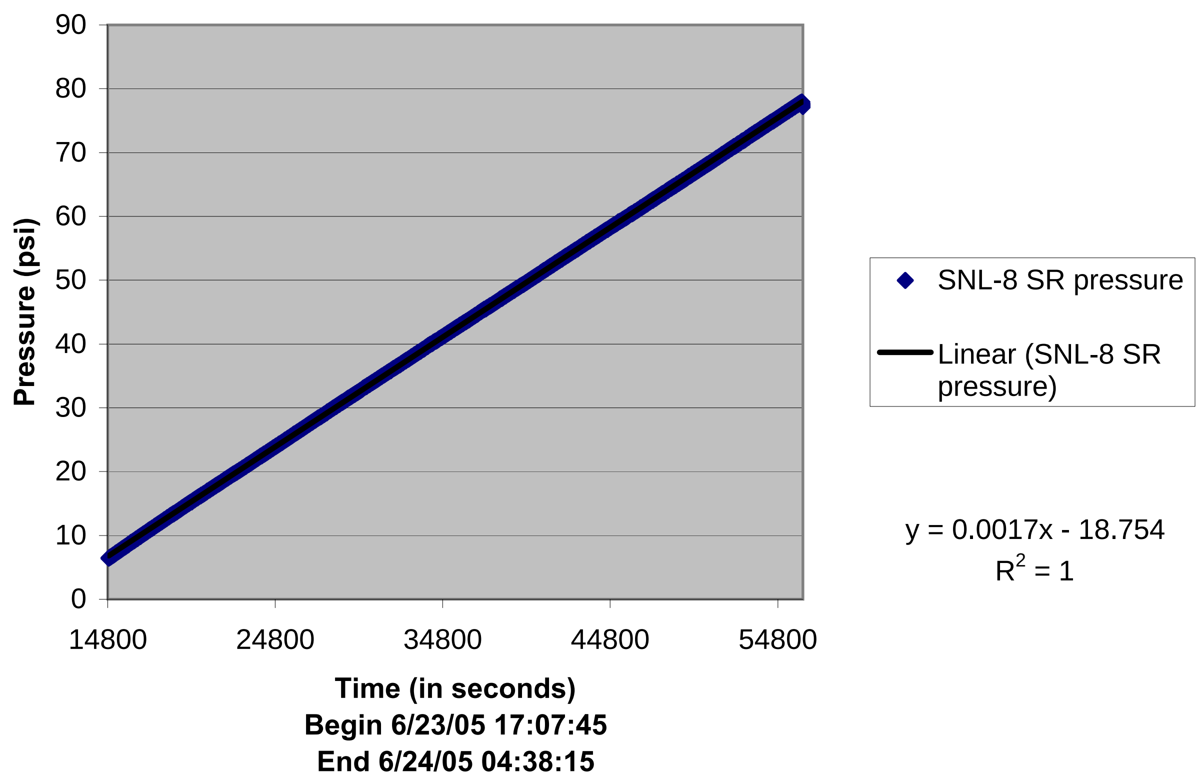
Shut Down time	Date/Time Measured	Depth to Water below pad level	11"Hole Depth at Measurement	GPM	Water rise (ft/hr)	Approximate water level elevation (m amsl)
6/15/05 13:04	6/16/05 7:30	182.9	255	0.32	3.91	1027.2
6/16/05 16:52	6/17/05 7:00	183.3	388	1.19	14.48	1027.1
6/17/05 12:04	6/20/05 7:55	183.9	453	0.33	3.97	1026.9
6/20/05 10:02	6/21/05 6:35	192.8	475	1.13	13.73	1024.2
6/21/05 8:02	6/22/05 7:19	195	483	1.02	12.37	1023.5
6/22/05 17:30	6/23/05 7:00	437.3	665	1.39	16.87	949.7
6/23/05 15:42	6/24/05 6:15	610	836	1.28	15.53	897.0
6/24/05 18:42	6/25/05 7:45	710.6	920	1.32	16.05	866.4

*At 836 ft, the drillhole bottom was in A-4, just above Magenta.
*At 920 ft, the drillhole bottom was in lower A-3 of the Tamarisk.

Note: Water was blown from drillhole at time of shutdown; no water in drillhole assumed for the purpose of estimating inflow.

Note: Ground level elevation is taken as 3553 ft for calculating water level elevation in meters above

Figure 3-1
Santa Rosa Pressure Increase in SNL-8



3.2 Initial Results From the Magenta Dolomite

The Magenta was drilled with compressed air and mist with soap. There were no indications of additional water inflow or accumulation from the Magenta during drilling.

The final overnight observation of fluid inflow from open hole above 920 ft (Table 3-1, June 25, 2005) does not differ significantly from observations at 836 and 665 ft, above Magenta.

3.3 Initial Results From the Culebra Dolomite

The Culebra was cored and then the well was reamed to 995 ft with compressed air and mist while blowing produced water from the open borehole. Water levels were not measured during this process.

WRES began monthly water-level monitoring of the Culebra on December 7, 2005; the initial depth to water was 526.59 ft below the top of casing (US DOE, 2006).

4.0 SIGNIFICANCE/DISCUSSION

The materials used in completing SNL-8 are expected to be stable over a lengthy monitoring period, in contrast to steel casing in monitoring wells drilled before 1995. Newer monitoring wells provide construction experience for groundwater surveillance wells that may be drilled in the future.

The lower Rustler and upper Salado were not penetrated at SNL-8. 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-8 was located far east of the upper Salado halite margin and is in the area where no halite has been dissolved. SNL-8 was also located west of the margin of halite in the three upper M/H units of the Rustler (Fig. 4-1), and it was particularly located to evaluate M-2/H-2 and M-3/H-3 margins. It is generally comparable to the locations for the H-19 hydropad (Mercer and others, 1998) and SNL-14 (Powers and Richardson, 2008).

No halite was recovered from cores through M-2/H-2, as expected. [Halite was encountered in the lower A-1 and upper M-1/H-1.] 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 core from SNL-8 was 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 was 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.

No halite was present in H-3/M-3 at SNL-8, as expected. The lower part of A-3 in core showed fracturing, some block rotation, and claystone and siltstone in the fracture zones. The fracturing and rotation is less than that at the H-19 pad (Mercer and others, 1998), but is more than was observed at SNL-14 (Powers and Richardson, 2008). Powers and others (2006) explored the distribution of halite in the Culebra and other Rustler units, including at SNL-14, -15, and preliminary data from SNL-8. Some H-3 appears to have been removed at the SNL-8 location after A-3 was lithified, resulting in some fracturing. In comparison, A-3 at SNL-14 appears to have not been affected by significant post-lithification removal of H-3; SNL-14 was located in the mudflat tract of the M-3/H-3 facies.

Culebra core recovery was complete. One reason may be the lack of porosity at SNL-8 because of less vug/nodule development and fill in most vugs. In addition, the drilling used compressed air and foam, and this may also have contributed to the success in core recovery. Fracturing was limited, and gypsum filled at least some of the fractures. The Culebra overall will likely have low transmissivity at SNL-8.

The Forty-niner also intercepted mudstone of the M-4/H-4 facies, showing a position within the mudflat environment where most WIPP drillholes are located.

Cuttings, drilling rates, and density logs suggest that fibrous gypsum and sulfate cements of the Dewey Lake occur below ~306–312 ft bgl. This position 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-8, or in any other part of the Dewey Lake.

The Santa Rosa is thicker at SNL-8 compared to most WIPP drillholes. Logs and cuttings indicate the Santa Rosa is interbedded sandstone and siltstones. Low specific gravity water in the lower Santa Rosa flowed at a rate estimated to be slightly greater than 1 gpm and a potentiometric surface estimated at ~1,027 m amsl.

The Gatuña is ~5 ft thick at SNL-8. The formation tends to be thinner, or not exist, in the eastern part of WIPP. SNL-8 is located along the eastern extent of a subdued valley that trends west-northwest across the northern side of WIPP and thence westward and northwestward towards Nash Draw. It appears that the valley has developed as part of Gatuña erosion and deposition. To the south, on a topographic high, the Santa Rosa crops out and has Mescalero caliche developed on it. Gatuña is thicker to the northwest in the center of the valley (e.g. at SNL-3; Powers and Richardson, 2004).

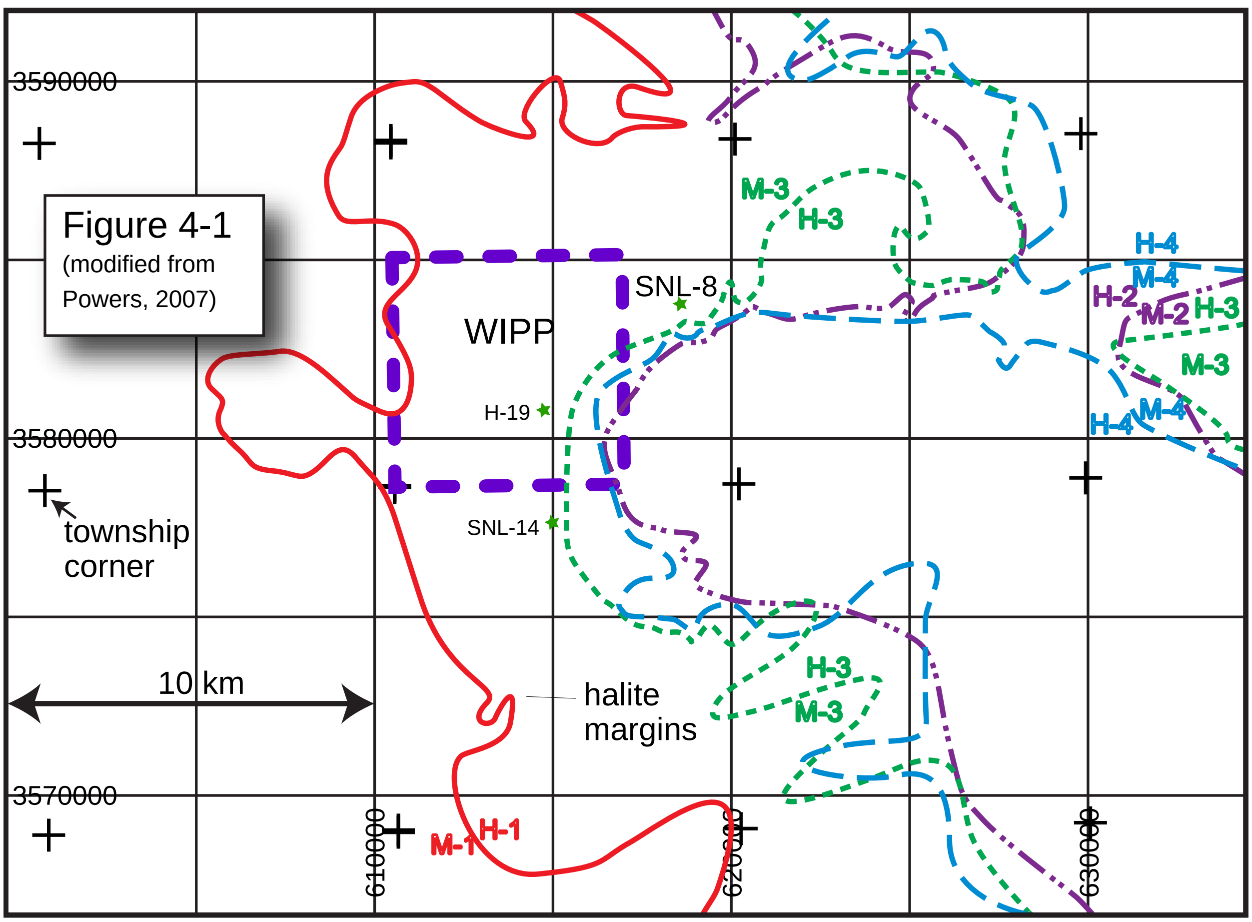


Figure 4-1. Location of SNL-8 relative to Rustler halite margins. H-19 and SNL-14 locations are shown relative to the same margins.

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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-8 was designated as a location in the original groundwater hydrology program (Sandia National Laboratories, 2003) with a parallel designation as WTS-8 to serve needs for the annual Hazardous Waste Facility Permit monitoring.

The material selected here for SNL-8/WTS-8 represent objectives excerpted from Sandia National Laboratories (2003). In addition, some material from one or more letter reports regarding the location has been excerpted where it is germane to SNL-8. Note that some pages reproduced here have been reduced in scale to fit the report page format.

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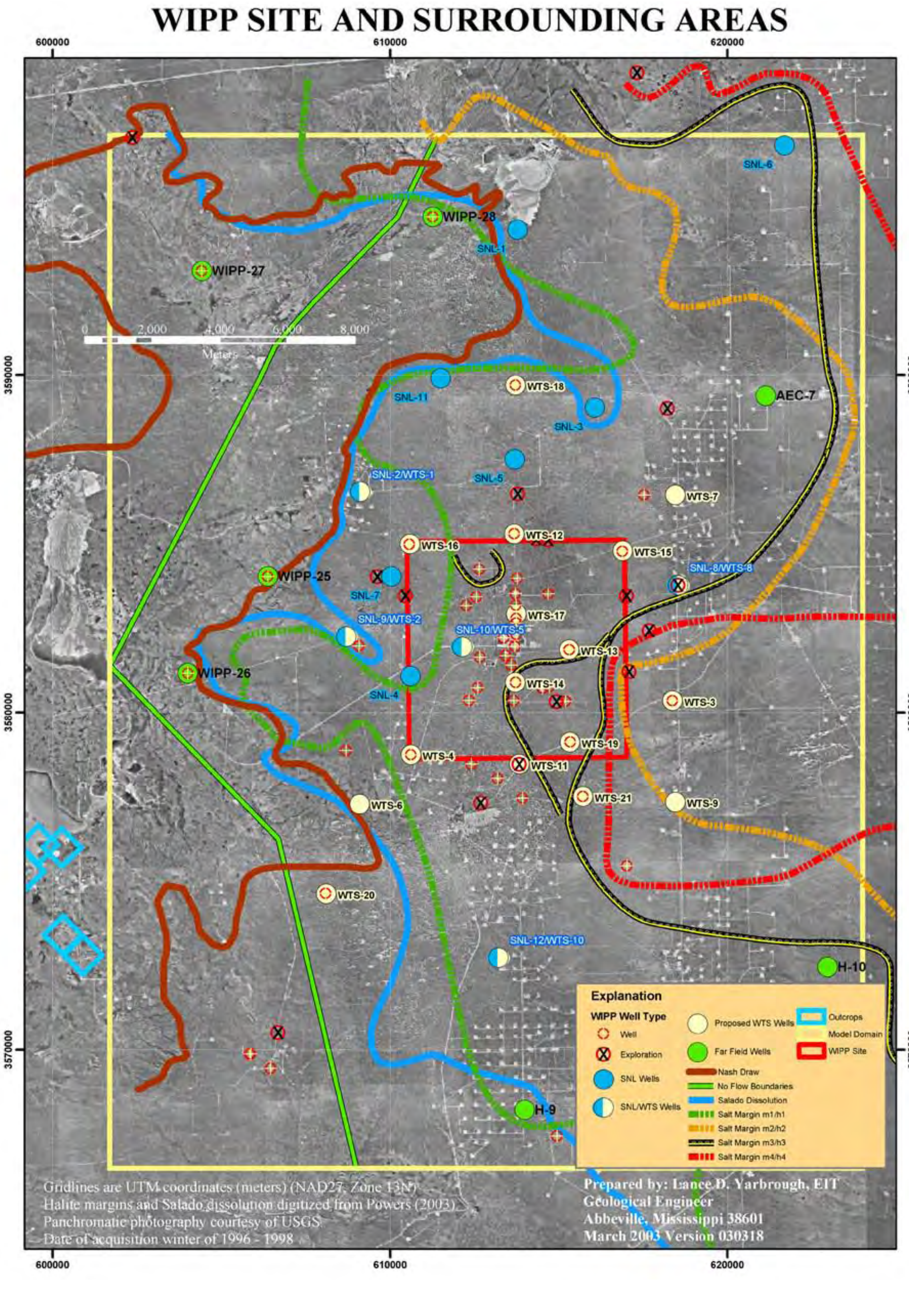
WIPP SITE AND SURROUNDING AREAS
600000
610000
620000
3590000
3580000
3570000
WIPP-28
WIPP-27
WIPP-25
WIPP-26
SNL-1
SNL-6
SNL-11
SNL-3
SNL-5
SNL-2/WTS-1
SNL-7
SNL-9/WTS-2
SNL-10/WTS-5
SNL-4
SNL-8/WTS-8
SNL-12/WTS-10
AEC-7
H-9
H-10
WTS-18
WTS-7
WTS-12
WTS-16
WTS-15
WTS-17
WTS-13
WTS-14
WTS-3
WTS-19
WTS-4
WTS-11
WTS-21
WTS-9
WTS-6
WTS-20
0 2,000 4,000 6,000 8,000
Meters
Explanation
WIPP Well Type
Well
Exploration
SNL Wells
SNL/WTS Wells
Proposed WTS Wells
Far Field Wells
Outcrops
Model Domain
WIPP Site
Nash Draw
No Flow Boundaries
Salado Dissolution
Salt Margin m1/h1
Salt Margin m2/h2
Salt Margin m3/h3
Salt Margin m4/h4
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-8/ WTS-8			X				X	

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SNL 8/WTS 8: A Culebra well will be installed at this location on the old P 20 drilling pad, east of the northern portion of the WIPP site (see Figure 8). This location is slightly west of the m3/ h3 halite margin. Our conceptual hydrogeologic model hypothesizes that dissolution of Rustler halite (and associated effects on Culebra transmissivity) may have occurred near the present-day margins. Some wells drilled near this margin (e.g., H 11, DOE 1) have shown high Culebra transmissivity, but others have not (e.g., H 15). A Culebra well at the SNL 8 location will serve the following purposes:

1. confirm the assumed low Culebra transmissivity east of the WIPP site; and
2. provide information on Culebra heads in an area with many nearby oil and gas wells.

In addition, a Culebra well at the SNL 8 location will provide needed information to help define the direction and rate of groundwater flow across the WIPP site, which is required for annual HWFP reporting to NMED (hence the parallel designation WTS 8).

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WTS-8/SNL-8: This well coincides with SNL 8 and will be installed on the old P 20 pad east of the northern portion of the WIPP site in an area with extensive drilling for oil and gas. This well will help to confirm the conceptual model assumption of low Culebra transmissivity east of the WIPP site.

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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-8/WTS-8		C			

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

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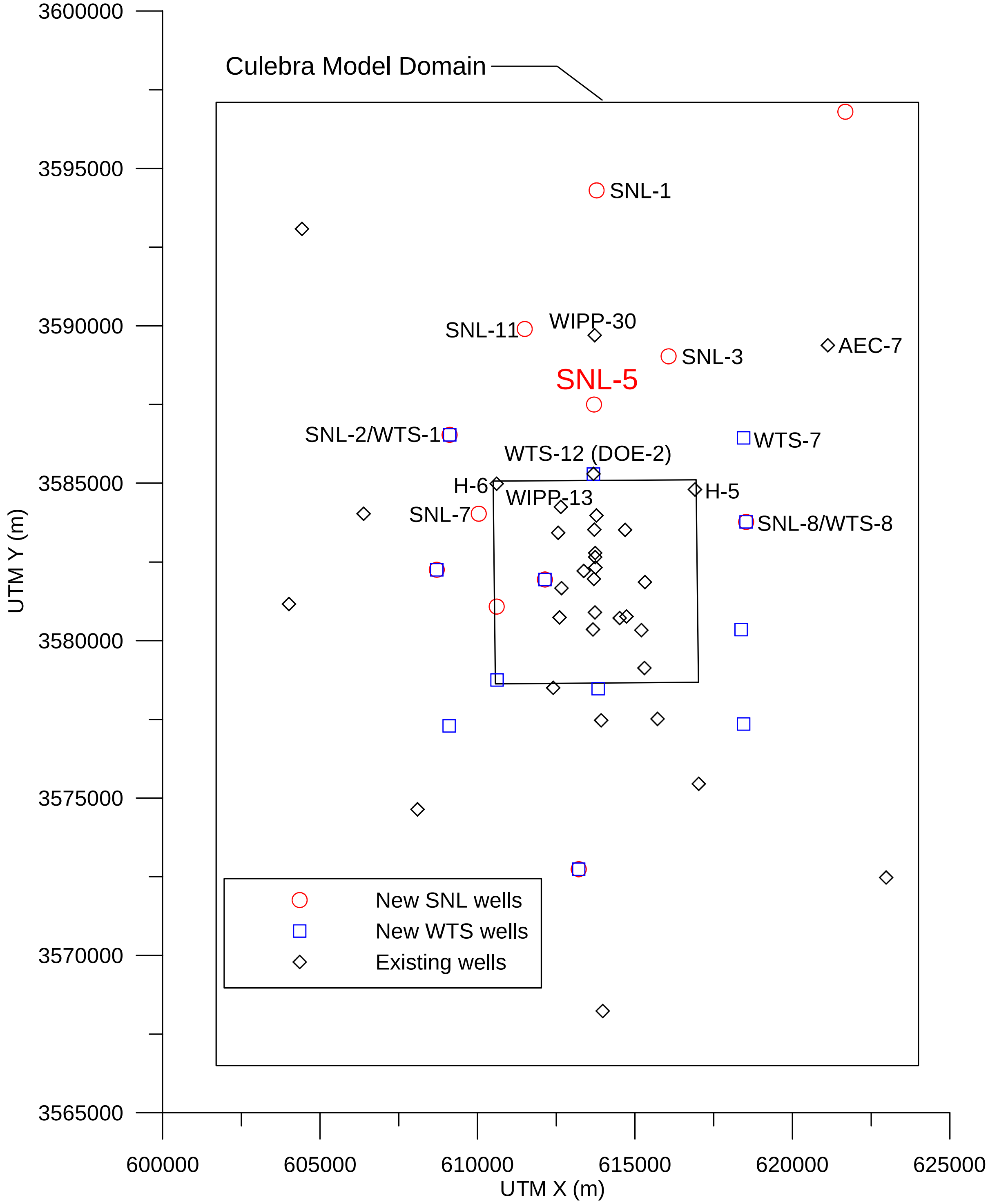

Figure 19. Pumping well and principal observation wells for northern multipad pumping test.

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6.1.3 FY05

Drilling in FY05 will focus first on the Culebra observation wells needed for the southern multipad pumping test planned for late FY05 (WTS 3, 9, and 11), followed by the replacement of plugged and abandoned well WIPP 28, then on the remaining new well east of the site (SNL 8/WTS 8), and finally on WTS 12, the replacement well for DOE 2. The latter three wells can be drilled during the southern multipad test without affecting that test. Magenta and Dewey Lake wells will be drilled after the Culebra wells are completed. Well CB 1 will be cleaned out to total depth and then cased through the evaporite section to provide a single-completion Bell Canyon well near the southern boundary of the WIPP site.

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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-8/ WTS-8	• low Culebra T	• establish connectivity with H-15, WQSP-4, and DOE-1 • site additional well to the southwest on the western side of the m3/h3 halite margin

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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-8/WTS-8	1000		

Dennis W. Powers, Ph. D.

Consulting Geologist

August 1, 2004

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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,

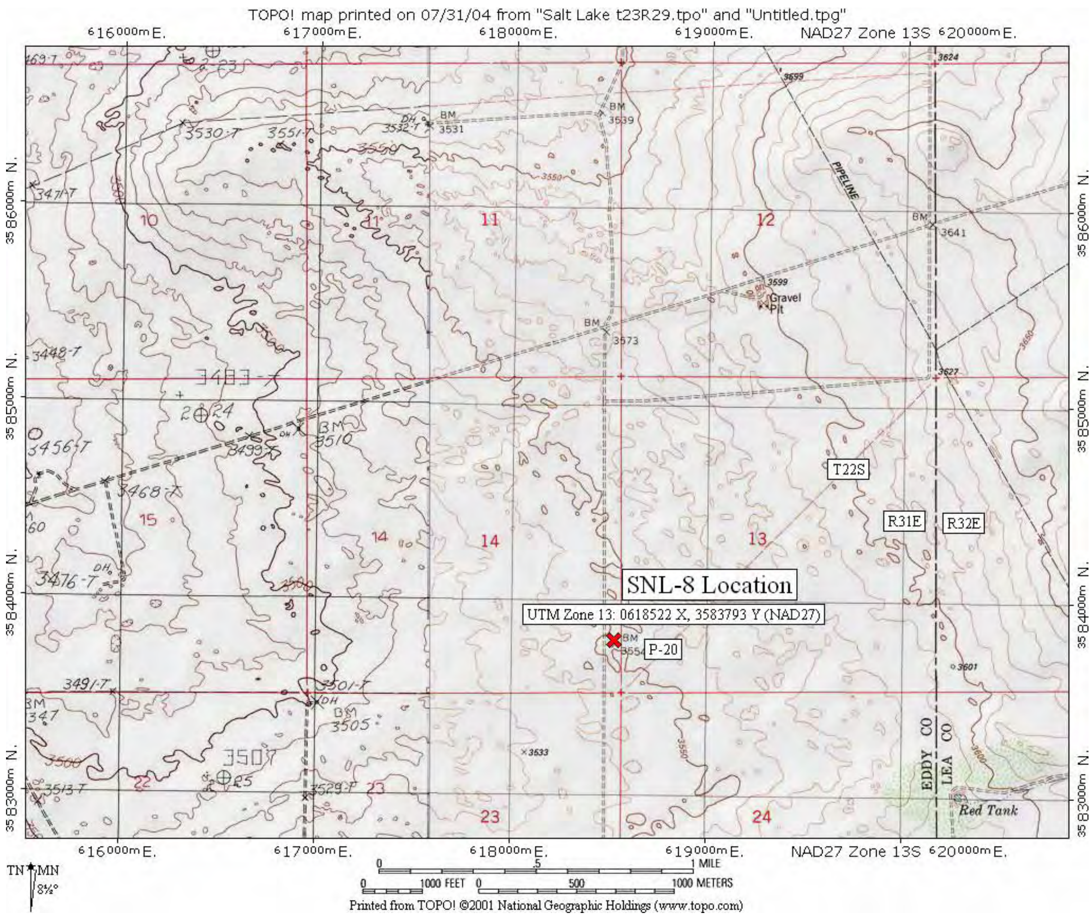
Dennis W Powers

Dennis W. Powers

NOTE: Some of the following pages of this memorandum have been omitted because they are not relevant to SNL-8.

Dennis W. Powers, Ph. D.
Consulting Geologist

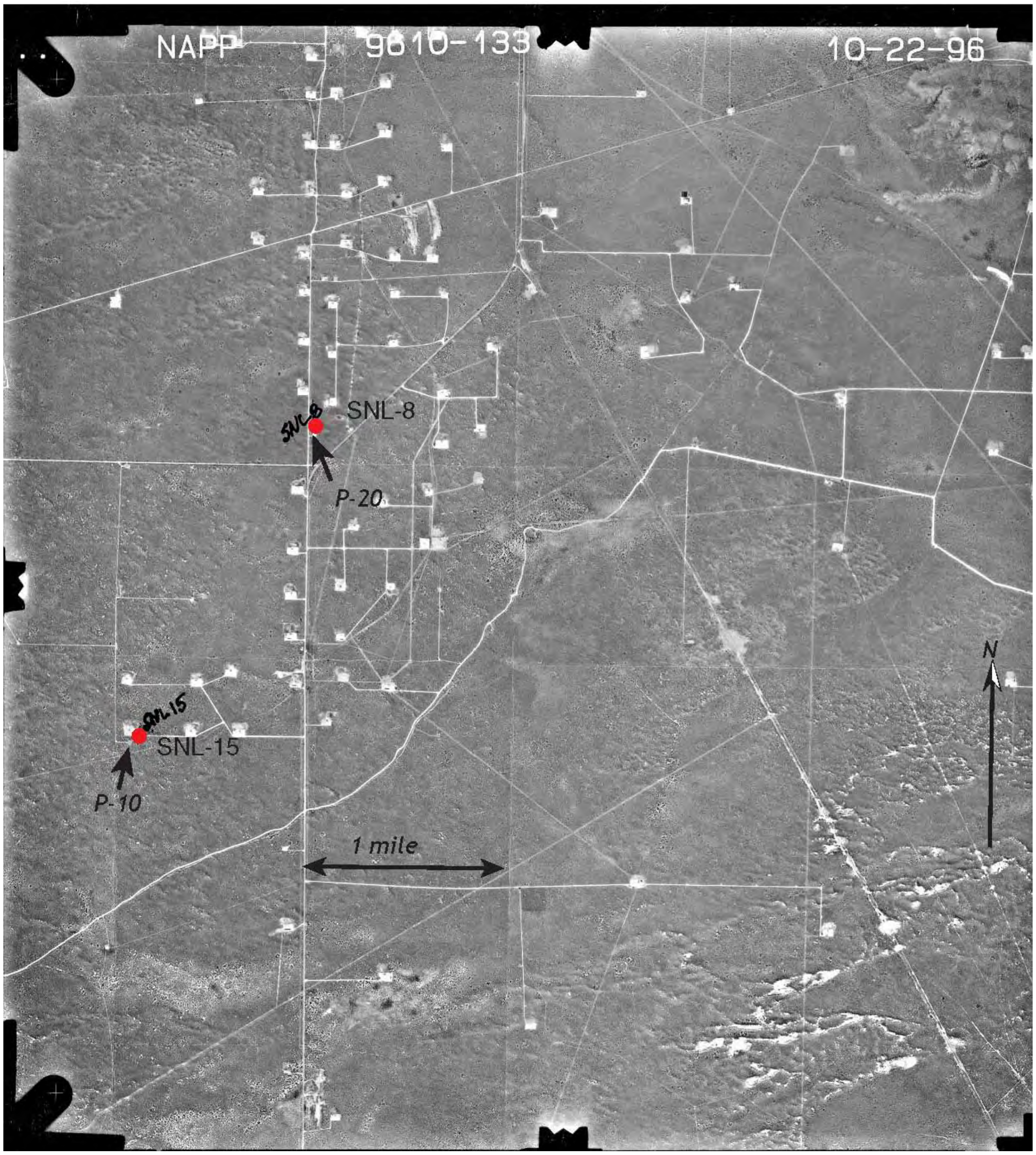
Assessing FY05 Drillhole Locations
August 1, 2004



Topographic map location of SNL-8. Bottom left is view of drilling location north of the P-20 pad. Bottom right is view of drilling location toward WIPP, on horizon.

Dennis W. Powers, Ph. D.
Consulting Geologist

Assessing FY05 Drillhole Locations
August 1, 2004



Aerial photograph showing locations of SNL-8 and SNL-15.

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.

NOTE: Portions of this memorandum not relevant to SNL-8 have been omitted, and some text has been placed without original page breaks.

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Dennis W. Powers, Ph. D.
Consulting Geologist

Drilling Estimates and Revisions FY2005
March 6, 2005

NOTE: Portions of this memorandum not relevant to SNL-8 have been omitted.

SNL-8

Prior Expectations for SNL-8

SNL-8 is located adjacent to the north edge of the drilling pad used for P-20. Because it is located west of the apparent margin of halite in M-3/H-3, it will provide information on the relationship of Culebra transmissivity to the presence or absence of salt in the unit. It also is in the vicinity of numerous oil and gas wells and will provide information on Culebra heads in such an area. The location of SNL-8 is also expected to provide information about the direction and rate of groundwater flow across the WIPP for annual reporting to the NMED. SNL-8 was originally scheduled to be drilled during FY05.

The hydrology plan generically indicated that wells such as SNL-8 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 Magenta and from above the Tamarisk mudstone into the upper Salado, a total of about 280 ft. This plan was based on the lack of detail for the mudstone/halite facies in all units, although the halite facies limits for each unit has already been estimated based on the descriptions from drillhole P-20. It is not believed that the upper Salado is being dissolved at this location and drilling was projected for about 100 ft below an expected top of Salado. Coring above and beyond the hydrology plan included the Forty-niner mudstone and basal anhydrite, and all of the Los Medaños plus a short interval in the upper Salado.

Current Plan for SNL-8

The location for SNL-8 has not changed. Halite is not anticipated in M-2/H-2, although the margin is not distant. The current location is not within the boundary for halite in either M-3/H-3 or M-4/H-4.

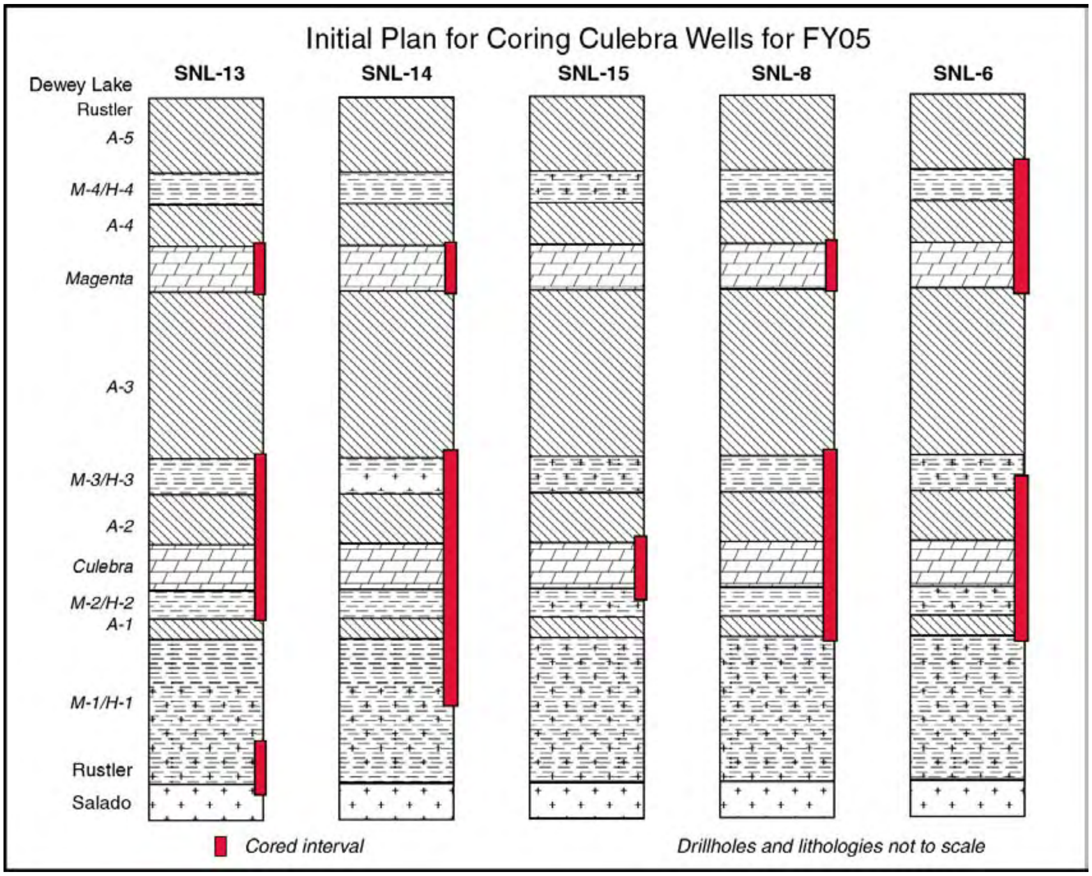
The revised drilling estimate is to a depth about 40 ft below the Culebra to try to establish the presence of halite in the upper part of M-1/H-1 and obtain some textural details through coring. The revised core interval eliminates coring of the Forty-niner mudstone to examine the M-4/H-4 halite margin; the Magenta is cored to provide regional data. The Tamarisk mudstone (M-3/H-3) above the Culebra is cored under this plan. It is expected that halite is not present in this unit. The lower Rustler and upper Salado are neither drilled nor cored in this revised plan.

The revised plan will eliminate coring and drilling of intervals through and around the Magenta as well as 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.

Dennis W. Powers, Ph. D.
Consulting Geologist

Drilling Estimates and Revisions FY2005
March 6, 2005

NOTE: Portions of this memorandum not relevant to SNL-8 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

Sunrise at SNL-8, June 16, 2005. Photo by 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 driller's log after allowing for the hour time difference. Drilling operations at SNL-8 were under restrictions through June 15 because the site is located in designated prairie chicken habitat. As a consequence, actual rig operations could not begin until after 09:00 MDT or 10:00 CDT for the first few days of operations at SNL-8.

6-13-05 Drove to SNL-8 site from Odessa, TX, arriving at 11:20 CDT (*see note above*). Conducted safety meeting. Set rolloff from Tripod. Worked on rotary table clutch. Drilled 17.50" hole to 37' from 11:55 to 14:00 using compressed air. Fished for bit and sub from 14:00 to 16:00. Ran 37' of 12.75" casing into hole from 16:00 to 16:10. Waited on cement. Cemented surface casing with 2.5 cubic yards of cement delivered by LaFarge, *formed pad*, and left site at 17:35.

6-14-05 Arrived on site at 10:08. Held safety meeting. Rigged up to drill; rigged up cat walk and pipe racks. Drilled 11" hole with air from 37' to 69' with reamers. Rigged up diverter for drilling with air and completed rigging up at 16:18. Drilled from 69'to 128' with air. Tripped out to collars by 18:35 and stopped drilling due to high winds and rain. Departed site.

6-15-05 Arrived on site at 10:10. Held safety meeting. Covered rolloff collecting cuttings. Tripped into hole and started drilling from 128' at 10:40. *No water in drillhole.* Encountered unconsolidated moist sand 175-180'. Reached 255' at 14:10 and halted drilling with hole making water. Tripped off bottom of hole with decision to convert to mist and soap; pit needs to be constructed as suitable frac tank not available. Water level measured at 255.75' below top of diverter (*1.70' above cement pad*) at 14:20. Shut down and departed site *at 16:15*.

6-16-05 Arrived on site at 07:45. Held safety meeting. On standby for backhoe to dig mudpit *and frac tank from SNL-13. Measured water level at 184.6' below top lip of diverter* (*1.70' above cement pad*) *at 08:30 indicates about 70' of water. Frac tank was delivered at 10:40.* Pit was finished and lined by 10:55. Tripped into hole from 10:55 to 11:23 to 255'. Drilled from 255' to 388' by 17:54; used 3 gallons of soap. Tripped out and shut down by 18:15 due to lightning in vicinity. Departed site at 18:25.

6-17-05 Arrived on site at 07:25. Held safety meeting. Tripped into hole by 08:00. Measured water level 185' below ground level at 08:00. Continued to blow water out to drilling point and began drilling with air and mist from 388' at 09:00. Drilled to 453' by 13:04 using 2 gallons of soap. Compresser went down. Tripped out to drill collars by 13:30. Shut down for weekend.

<u>6-20-05</u> Arrived on site at 07:30. Held safety meeting. Began tripping into hole at 07:40. Measured water level at 185.6' below top of diverter *(1.7' above cement pad)* at 08:55. Completed tripping into hole, blowing water while progressing. Reached 453' and began drilling at 09:43 with air and mist. Reached 475' at 11:02; shut down because compressor required service. *Action Safety on site 11:55-12:20 for inspection.* Wagner on site to service compressor 12:02. Bad water pump on compressor; *will need to get pump from Hobbs*. Tripped out of hole to collars from 12:50 to 13:20. Suspended drilling for day while compressor is repaired.

<u>6-21-05</u> Arrived on site at 07:10. Held safety meeting. Began tripping into hole at 07:20 to 200'. Measured water level at 194.4' below top of diverter *(1.7' above cement pad)* at 07:38 with bit at 200'. Continued tripping in while blowing out water column. Reached 475' and began drilling at 08:30. Reached 483' at 09:02. Compressors failed. Tripped out to drill collars and shut down drilling for the day. WTWWS replacing compressors.

<u>6-22-05</u> Arrived on site at 07:20. Held safety meeting. Rigged up compressor from Wagner. Began tripping into hole to 200' at 07:57. Measured water level at 196.7' below top of diverter *(1.7' above cement pad)* at 08:19. Continued tripping in while blowing out water column. Reached 483' and rigged up additional compressor. Began drilling at 10:00. Reached 665' at 18:37; used 4 gallons of soap. Blew well until 18:45. Tripped out to drill collars and shut down drilling for the day at 19:20. Shut down and left site.

<u>6-23-05</u> Arrived on site at 07:20. Held safety meeting. Began tripping into hole at 07:30. Measured water level at 439' below top of diverter *(1.7' above cement pad) at 08:01*. Continued tripping in while blowing out water column. Reached 665' and began drilling at 09:06. *LeaLand arrives on site at 09:55 to remove rolloff #0016. Action Safety on site for inspection at 10:25; left 10:45. Four Star Rental leaves frac tank on site at 12:35.* Reached coring point at 836' at 16:33; used 10 gallons of soap. Blew water from hole until 16:42. Tripped out by 17:50 and shut down drilling. *Installed miniTroll in well to 797.4' below top of surface casing.*

<u>6-24-05</u> *Water level estimated ~610' below surface casing; foam in hole causes problems measuring water level with Solinst. Removed miniTroll from well from 06:25 to 06:45.* WTTWWS arrived on site at 07:10. Held safety meeting. *Billy Pon (DOWDCO) arrived on site at 07:15.* Installed diverter and assembled core tool by 09:35. Began tripping into hole at 09:35, unloading water in hole while tripping in. Reached 836' at 10:50 and began coring. Reached 866' at 11:15 and began to trip out with core. Laid core down from 12:25 to 12:40; *recovered 100%*. Reassembled core tool and laid down. Picked up 11" bit and collars. Reinstalled diverter by 14:20. Tripped in from 14:20 to 15:15 and began reaming cored section. *Began drilling new hole from 866' at 17:03.* Reached core point at 920' at 19:34. Blew well dry and tripped out by 20:20.

<u>6-25-05</u> WTTWWS arrived on site at 07:40. Held safety meeting. Finished tripping out of hole to changeover to coring. *Water level 710.6' below top of diverter (1.7' above cement pad) at 08:45.* Assembled core tool, installed diverter, and began tripping into hole by 09:55, unloading water in hole while tripping in. Reached 920' at 12:06 and began coring. Reached 935.5' at 12:50. Core barrel jammed; began to trip out with core. Laid core down from 14:18 to 14:30, recovering 14.5’. Reassembled core tool and tripped to bottom by 16:13. Cored from 935.5’ to 965.5’ by 18:00. Blew water down to 18:05. Tripped out by 18:50. Left core in barrel overnight. Used 7 gallons of soap while coring.

6-26-05 Arrived on site at 07:15. Held safety meeting. Retrieved core barrel and laid down core by 08:40. Recovered 100%. Reassembled core tool and tripped to coring point by 12:19. Cut core from 965.5’ to 994’ by 13:20. Tripped out with core barrel and laid core down by 15:20; recovered 100%. Reassembled core tool and tripped in to 994’ by 16:30. Cored to 1012’ by 16:55. Tripped out of hole by 17:45. Left core in core barrel overnight and shut down. Used 5 gallons of soap during coring. Placed 7 bags of HolePlug® from 1012’ to 991’.

6-27-05 Arrived on site at 08:15. Held safety meeting. Laid core down by 08:45; 100% recovery. *Placed seven bags of HolePlug® in drillhole to plug back to 991’*. Broke down core tool by 09:20. Removered diverter by 10:10. Picked up 11” rotary bit and tripped into hole by 11:45 to ream out cored interval. Reached completion depth of 995’ at 17:35. Blew water from hole until 17:52. Tripped out and laid down pipe and bit by 19:00. Used 7 gallons of soap and 3 gallons of EZMud® while reaming.

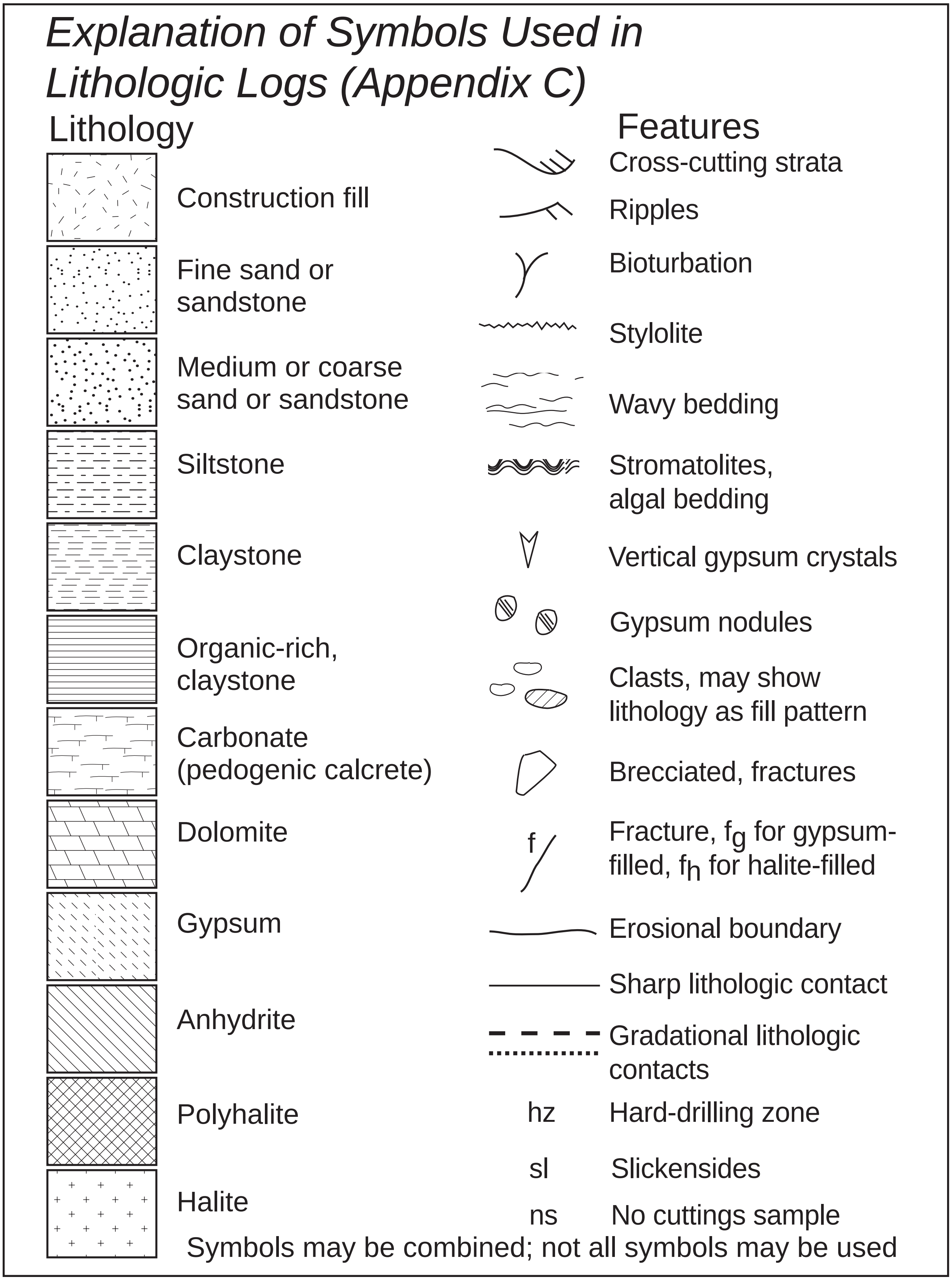
6-28-05 Arrived on site at 07:05. Held safety meeting. Rigged up for geophysical logging *by JetWest logging from Farmington, NM*. Started logging at 08:05 and finished at 10:35. Hole open to 981.5’. Tallied tremmie pipe and casing by 11:10. Ran tremmie pipe in hole by 13:00. Casing run in hole by 15:12. Rigged up to run gravel pack and finished pumping 2000 pounds of gravel (4/10) by 16:52. Installed HolePlug® (8 bags) from 16:52 to 17:10. State Engineer representative (Mike Stapleton) onsite at 17:15. Waited on cement. Pumped cement from 17:30 to 19:15. Cement returned to surface at 19:15 and Stapleton leaves site. Tremmie line removed from well at 19:25. Note: used 450 barrels of WIPP site water while drilling hole.

7-06-05 WTWWS arrived on site at 10:20 to attempt to bail well dry. Well was filled with fresh water (from WIPP site) during cementing of annulus. Initial water level is just over 500’ below top of casing at 11:20. Start bailing at 11:30. Removed 56 bailers of water from well. Water level greater than 950’ below top of casing by 14:15. Stopped for day because rig hydraulic fluid was too hot. Well can easily be bailed dry, even with stops for oil to cool and well to recover.

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.


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
f
Fracture, fg for gypsum-filled, fh 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 9

Hole ID: SNL-8	Location: SE 1/4, section 14, T22S, R31E, Eddy Co, NM	
Drill Date: 6/13/2005 Drill Crew: West Texas Water Well Service; Larry Keith, Luis Armendariz	Drill Method: Rotary with air, mist Hole Diameter: initial 11 inches Hole Depth: Hole Orient: vertical downward	Drill Make/Model: Gardner-Denver 1500 Barrel Specs: 6.75 in o.d., 4 in. core Drill Fluid: air; variable Core Preserv: box as is
Logged by: Dennis W. Powers, Ph.D., consulting geologist	Date: 6/13-14/2005	Scale: variable

	Northing	Easting	Elevation
Survey Coordinate: (NAD27 m)	3583783.35	618522.82	3553 ft amsl

Comments: SNL-8 has been permitted by the New Mexico State Engineer as C-3150.

Run Number	Depth ( )	% Recovered	RQD	Profile (Rock Type)	Description	Remarks Start 6/13/07 all times MDT
N/A	0	N/A	N/A		0-10’: Dune sand, fine-medium, reddish brown	Begin 1055
		C-1			10-15’: Mescalero caliche; sand, very calcareous, to sandy limestone; with reddish brown siltstone and sandstone clasts (Santa Rosa Fm clasts)	10’ @ 1100
	20	C-2			15-20’: Gatuña Fm: sand, as above, less calcareous downward	20’ @ 1118
					no sample (ns) at 30’	25’ @ 1129; clear dirt; begin 1136 30’ @1152 35’ @ 1154; stop to set casing to 37‘; end 6/13/07 Begin 6/14/07
	40	C-3			40’: Santa Rosa Formation: sandstone, weak red (2.5YR5/2); very fine to fine, coated grains with clay matrix.	40’ @ 1140 45’ @ 1144
		C-4			50’: as above	50’ @ 1152 55’ @ 1202
	60	C-5			60’: as above, some tiny whitish spots	
		C-6			70’: as above, slightly coarser sand: very fine to medium	65’ @ 1212; rig maintenance; add jt 70’ @ 1519 75’ @ 1528
	80	C-7			80’: sandy siltstone	80’ @ 1544
		C-8			90-100’: sandstone, very fine to medium, similar to 70’	85’ @ 1554 90’ @ 1600 95’ @ 1610; add jt; begin 1630 100’ @ 1643
	100	C-9				

Hole ID: SNL-8 | CORE LOG (cont. sheet) | Sheet 2 of 9

Logged by: Dennis W. Powers, Ph.D. | Date: 6/14-16/05

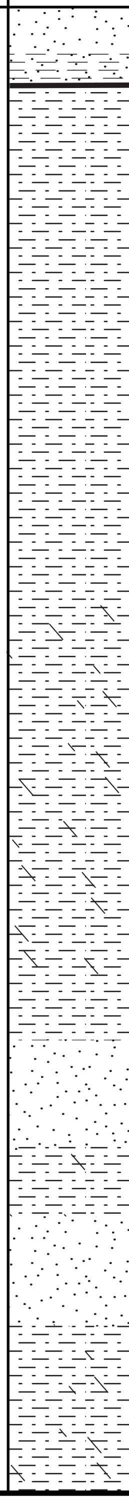
Run Number	Depth (ft)	% Recovered	RQD	Profile (Rock Type)	Description	Remarks all times MDT
N/A	100	N/A	N/A			105' @1650 MDT
					110-120': sandstone, as above, with argillaceous siltstone	110' @ 1655 115' @ 1707
	120	C-11				120' @ 1712
		C-12			130': sandstone, fine to medium, subangular to subround, calcareous, weak red (10R5/4), some opaques	125' @ 1718, add jt; begin 1730; end @ 128' 6/14/05 begin 0942 MDT
	140	C-13			140': sandstone, as above, mixed with sandstone, light gray (10YR7/2), generally medium sand with some fine, rounded, calcareous; some light gray siltstone and claystone	6/15/05 @ 128' with air 130' @ 0944 135' @ 0951
		C-14			150': similar to 140', grains less well sorted, more angular than better sorted and rounded chips @ 140'.	140' @ 0956 145' @ 1001
	160	C-15				150' @ 1008 152' @ 1013, add jt begin 1023
		C-16			170': loose sand, calcareous; (10YR6/3); cuttings damp	155' @ 1026 160' @ 1033 165' @ 1039
	180	C-17			175': 5YR5/3 178': 10YR6/3 180': mixed gray and weak red	170' @ 1044 175' @ 1050 180' @ 1057
		C-18			185': 10R4/2 190': as above	185' @ 1103 add jt begin 1133
	200	C-19			197': more sandy siltstone and argillaceous siltstone, little sandstone; slightly calcareous to very calcareous 200': 10R4/2 as above	190' @ 1140 195' @ 1146 200' @ 1150 205' @ 1154
		C-20			210': damp sand	210' @ 1159 215' @ 1205 216' @ 1207, add jt, begin 1216
		C-21				
	220	C-22			220': sandy siltstone (2.5YR5/4)	220' @ 1220 225' @ 1223 230' @ 1226
		C-23			230': silty sandstone and sandy siltstone (5YR5/2) with some siltstone (2.5YR5/4)	235' @ 1231 240' @ 1236 245' @ 1240, add jt, begin 1254
	240	C-24			240': siltstone, with some sandy siltstone and argillaceous siltstone (2.5YR5/2 and 10YR7/2)	250' @ 1257; wet 255' @ 1304; end drilling 6/15/05
		C-25			250': Sand, very fine to fine, silty (2.5YR5/4), friable and moist, non-calcareous, subangular grains	6/16/05 water level 184.6' @ 0730 MDT; begin drilling with air & mist from 255'
	260	C-26				260' @ 10:29

Hole ID: SNL-8 | CORE LOG (cont. sheet) | Sheet 3 of 9

Logged by: Dennis W. Powers, Ph.D. | Date: 6/16-17/05

Run Number	Depth (ft)	% Recovered	RQD
N/A	260	N/A	N/A
		C-27	
	280	C-28	
		C-29	
	300	C-30	
		C-31	
	320	C-32	
		C-33	
	340	C-34	
		C-35	
	360	C-36	
		C-37	
	380	C-38	
		C-39	
	400	C-40	
		C-41	
	420	C-42	

Profile (Rock Type)



Description

260': Sandstone, white (10YR6/2, fine to medium, and siltstone, argillaceous, sandy, (2.5YR5/2)

268' Base of Santa Rosa Fm
Top of Dewey Lake Fm

Siltstone and silty claystone, weak red (2.5YR4/2; wet), with some small gray flecks; very slightly calcareous; gray (5Y5/1, wet) spots as well as chips beginning from about 300'; sandy samples are micaceous.
284': hz

290-310': as above

298': hz

301': hz
306': hz, some white, fine crystalline spots showing crystal faces or cleavage, very hard

312': sandy, micaceous, possibly somewhat siliceous, drills slowly 312-315'.
317': hz
320': gypsum encountered
323': hz

330-360': as above, with gypsum

370': sandstone, fine to very fine, well cemented, not calcareous, subround to round grains; probably lower sandstone (ss1)

380': siltstone, silty claystone

390': sandstone, hard, slightly calcareous; begin reddish brown (2.5YR4/4), less intense value than above

400': siltstone, sandy, argillaceous, with fibrous gypsum along fractures

410-420': as above

Remarks all times MDT

265' @ 1034 MDT
270' @ 1040
275' @ 1046
279' @ 1059; add jt begin 1137
280' @1138
285' @1145
290' @ 1153
295' @ 1157
300' @ 1204
305' @ 1209
310' @1218
311' @ 1220, add jt; begin @ 1235
315' @ 1248
320' @ 1301
325' @ 1312
330' @ 1321
335" @ 1334
340' @ 1435
342' @1439, add jt, begin @ 1450
345' @ 1453
350' @ 1502
355' @ 1528
360' @ 1535
365' @ 1542
370' @ 1600
372' @ 1609; add jt begin 1628
375' @ 1632
380' @ 1637
385' @ 1647
388' @ 1652; shut down for weather
Begin 0800 6/17/07 @ 388'; water 185' below diverter @ 0700
390' @ 0810
400' @ 0828
410' @ 0837
412' @ 0839, add jt, circulate hole, begin 0858
420' @ 0907

Hole ID: SNL-8 — CORE LOG (cont. sheet) — Sheet 4 of 9

Logged by: Dennis W. Powers, Ph.D. — Date: 6/17/05, 6/20-22/05

Run Number	Depth (ft)	% Recovered	RQD	Profile (Rock Type)	Description
N/A	420	N/A	N/A		
		C-43			430-440': as above
	440	C-44			
		C-45			450': siltstone, as above, and sandstone, very fine to fine, grayish brown (2.5Y5/2), noncalcareous, well-indurated, rounded grains; no gypsum noted
	460	C-46			460-480': siltstone, sandy, reddish brown, with some grayish brown sandstone; gypsum, clear, fibrous; small gray reduction spots
		C-47			
	480	C-48			484': hz
		C-49			490': as above, very little gypsum or none
	500	C-50			500': as above, little gypsum
		C-51			510': as above, some gypsum
	520	C-52			520': as above, little gypsum
		C-53			530-540': as above, more gypsum (estimate 5%)
	540	C-54			
		C-55			550': as above, less gypsum (1-2%)
	560	C-56			560': as above, more gypsum (2-5%)
		C-57			570-580': as above, with more gray siltstone (5-10% gypsum)
	580	C-58			

Remarks (all times MDT)

430' @ 0946
435' @ 0957
440' @ 1006
443' @ 1018; add jt begin 1121
445' @1130
450' @1151
453' @ 1204; end drilling, compressor problems
Begin 6/20/05 water level 185.6' below diverter rim @ 0755; begin from 453' @ 0845
460' @ 0903; compressor off 0910-0912
465' @ 0920
470' @ 0941
475' @ 1002; compressor down, end drilling
Begin 6/21/05 water level 194.5' below diverter rim @ 0635; begin @ 0730
480' @ 0747
483' @ 0802; compressor out; end drilling
Begin 6/22/05 water level 196.7' below diverter rim @ 0719; begin @ 0900
485' @ 0905
490' @ 0933
495' @ 0958
500' @1015
505' @ 1034
507' @ 1044, add jt, begin 1055
510' @ 1104
515' @ 1114
520' @ 1128
525' @ 1147
530' @ 1206
539' @ 1244; add jt begin 1255
540' @ 1257
545' @ 1310
550' @ 1327
555' @ 1344
560' @ 1351
565' @ 1358
570' @ 1407, add jt, begin 1416
580' @ 1444

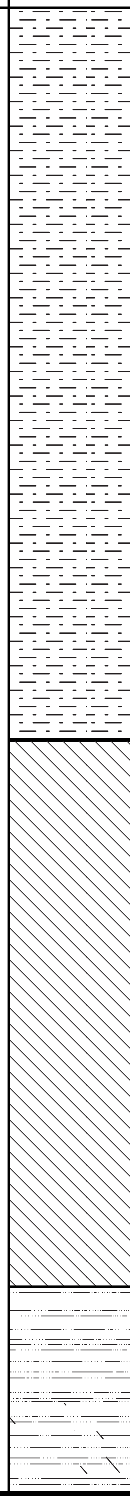
Hole ID: SNL-8 | CORE LOG (cont. sheet) | Sheet 5 of 9

Logged by: Dennis W. Powers, Ph.D. | Date: 6/22-23/05

Run Number	Depth (ft)	% Recovered	RQD	Profile (Rock Type)	Description	Remarks all times MDT
N/A	580	N/A	N/A			585' @ 1457
		C-59			590-670': as above, less greenish gray siltstone	590' @ 1528
	600	C-60				600' @ 1544 602' @ 1547; add jt begin 1557 605' @1602
		C-61				610' @1608 615' @ 1614
	620	C-62				620' @ 1620 625' @ 1626
		C-63				630' @ 1635 634' @ 1639; add jt, begin 1651 635' @ 1652
	640	C-64				640' @ 1700
		C-65				645' @ 1708 650' @ 1715
	660	C-66				655' @ 1723 660' @ 1731 665' @ 1737, end drilling 6/22/05
		C-67				Begin 6/23/05 @ 0806 from 665'
	680	C-68			680-690': as above, less gypsum (1-2%)	670' @ 0811 675' @ 0826 680' @ 0829
		C-69				685' @ 0840 690' @ 0847 694' @ 0853; add jt begin 0958 695' @ 1000
	700	C-70			700-779': as above, includes small white spots (< 0.06 inch) of probable gypsum	700' @ 1009 705' @ 1014
		C-71				710' @ 1021 715' @ 1026
	720	C-72				720' @ 1031, 724' @ 1035, add jt, begin 1051 725' @ 1054
		C-73				730' @ 1100
	740	C-74				735' @ 1106 740' @ 1111

Hole ID: SNL-8 | CORE LOG (cont. sheet) | Sheet 6 of 9

Logged by: Dennis W. Powers, Ph.D. | Date: 6/23/05

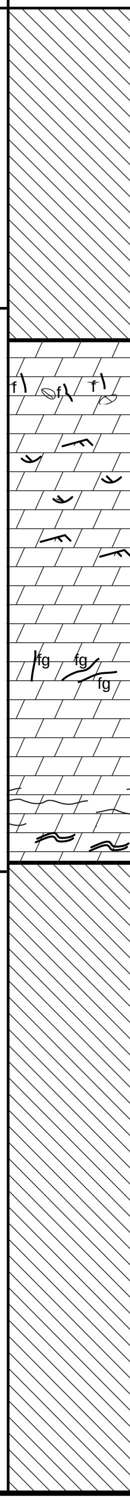


Run Number	Depth (ft)	% Recovered	RQD	Profile (Rock Type)	Description Note scale change	Remarks all times MDT
N/A	740	N/A	N/A		700-779': as above, includes small white spots (< 0.06 inch) of probable gypsum	745' @ 1116
	750	C-75				750' @ 1120 755' @ 1125 756' @ 1126; add jt begin 1142
	760	C-76				760' @1145 765' @ 1152
	770	C-77				770' @ 1158 775' @ 1203
	780	C-78			779' Base of Dewey Lake Formation Top of Rustler Formation 780': mixed gypsum/anhydrite chips with siltstone	780' @ 1207 785' @ 1227 787' @ 1234, add jt begin 1257
	790	C-79			790-808': gray to white anhydrite A-5	790' @ 1311 795' @ 1328
	800	C-80			808-820': siltstone, sandy, reddish brown at top, underlain by siltstone, gray (5YR4/1; dark gray when damp); with gypsum	800' @ 1348 805' @ 1410,'
	810	C-81			H-4/H-4	810' @ 1419 815' @ 1421 818' @ 1424; add jt begin 1438
	820	C-82				820' @ 1444

Hole ID: SNL-8 CORE LOG (cont. sheet) Sheet 7 of 9

Logged by: Dennis W. Powers, Ph.D. Date: 6/23-24/05

Run Number	Depth (ft)	% Recovered	RQD	Profile (Rock Type)	Description	Remarks all times MDT
N/A	820	N/A	N/A		830-846': anhydrite, gray A-4 836-837.6': Anhdrite and gypsum, gray; with coarse clear gypsum; some carbonate laminae (0.04-0.08 inch thick) spaced 0.08-0.16 inch apart	825' @ 1459 830' @ 1513 835' @ 1532 836' @ 1536; end 6/23/05; prepare for coring Install miniTroll @ 797.4' below top of casing at 1715
	830	C-84				
1	840 850 860	Cored 30', recovered 30' (100%)	All segments > 4"; (RQD=100.0)		837.6' Base of Forty-niner Member Top of Magenta Dolomite Member Dolomite, gypsiferous, interbedded 5Y6/2 and 5Y7/2 ; 5Y5/2 in more porous zones; high relief fine laminae (algal) near base, becoming wavy to laminar upwards; basal and upper contacts sharp (< 0.5 inch). 837.6-839.8': fibrous gypsum along bedding; gypsum (anhydrite?) sand, medium-coarse, possibly graded; erosional relief on several surfaces, cross-cutting @ 839.8' 839.8-840.7': very fine sand to silt size grains; bedding indistinct, flat to low angle; very narrow (<0.01 inch) vertical fractures; small nodules in upper 0.3 ft. 841-840.7': small white gypsum nodules or clasts; flat bedding, laminae (<0.20 inch) thick 841.8-841': scattered nodules or clasts; cross-cutting bedding, ripple sets to ~1 inch thick 848.5-841.8': very fine sand to silt size dolomite with similar size porosity; alternating dark-light laminae, with sets ~1 inch thick; cross-cutting bedding and relief; ripples to 0.5 inch. 860-848.5': silt sized dolomite; laminae nearly horizontal; some lighter colored starved ripples; rare gypsum along bedding plane separations 864-860': distinct wavy fine laminae (<0.05 inch) with 1 inch relief, stacked, probably algal. 865.4-864': laminar, irregular bedding around gypsum, high relief, algal. fg: 854.7-854.1', 3 fractures (40^o, 25^o, 80^o) with near-vertical fibrous gypsum, separation ~0.1 inch, slight downdrop on 80^o fracture. f: 840.7-839.8', narrow (<0.01 inch), vertical, short	Begin 6/24/05 water level estimated @ ~610' due to foam in hole; removed miniTroll @ 0530 Cored from 836' to 866' end coring 866' @ 1015; ream to 866' Begin drilling.
N/A	870	N/A C-85	N/A		865.4' Base of Magenta Dolomite Member Top of Tamarisk Member Gypsum and anhydrite, gray, laminar to possibly nodular at top in transition to dolomite and algal bedding	870' @ 1618 875' @ 1632
	880	C-86				880 @ 1645 882' @ 1650, add jt begin 1750
	890	C-87			as above A-3	890' @1718 895' @ 1749
	900	ns				900' @ 1738



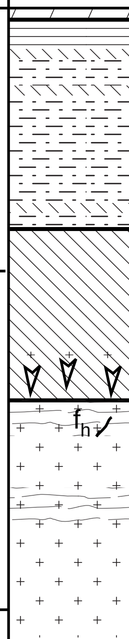
Hole ID: SNL-8 | CORE LOG (cont. sheet) | Sheet 8 of 9

Logged by: Dennis W. Powers, Ph.D. | Date: 6/24-25/05

Run Number	Depth (ft)	% Recovered	RQD	Profile (Rock Type)	Description	Remarks all times MDT
N/A	900	N/A; C-84	N/A		A-3 910': anhydrite, gray	905' @ 1749 910' @ 1759 915' @ 1822
2	920–930	Cored 15.5', recovered 14.5' (93.5%)	9.9' in segments > 4"; (RQD=68.3)		931-920': Anhydrite, gray, dark to light; bedded to laminar (0.04 inch thick); bedding dips variably, up to 45^o in general, higher near base. Fractures from near vertical to ~ 45^o, some breaks parallel to bedding at low angles; gray claystone or siltstone fills most fractures, some too narrow to observe fill; most fractured and brecciated from 978-927'. 931.0' M-3/H-3 939-931': Claystone and silty claystone, reddish brown (5YR4/4) with clasts of light gray (2.5Y7/0) silty sandstone ranging to 0.5 inch diameter and larger (2-4 inch) clasts, generally angular, of anhydrite; smaller clasts in lower 0.5' are more rounded; some anhydrite clasts are finely laminar. Slickensides on claystone range from ~50-60^o to subhorizontal; some blocks show facets with differing orientations of striaea.	920' @ 1834; change to coring Begin 6/25/05 to core from 920' core loss assumed at base of run 2
3	940–960	Cored 30', recovered 30' (100%)	27' in segments > 4"; (RQD=90.0)		939.0' A-2 954.6-939.0': Anhydrite, medium gray, fine crystalline, laminar to bedded; bedded nodular zones in lower part and possibly nodular in upper part; possible pseudomorphs of gypsum growth crystals indicated by sharply crinkled bedding in lower part; possible algal laminae @ 945.5'. 945.0-944.5': siltstone and claystone, grayish to purplish brown, that divides A-2, laminar with some folding near top, sharp erosional basal contact and grades into sulfate at top. 954.6' Base of Tamarisk Member Top of Culebra Dolomite Member 963-954.6': dolomite, sandy (more so in lower 4'), thin beds to fine laminae, with very fine, organic laminae at top; bedding slightly undulatory; scattered vugs to 0.5 inch, some filled with gypsum; irregular near-vertical fractures with narrow apertures and little evidence of fill. 968-963': dolomite, fine grained, thin laminae and beds ~horizontal and parallel; rare vugs with gypsum; vertical, orthogonal fractures without fill, block width ~3 inches; silt lamina at 974'.	
4	970–980	Cored 28.5', recovered 28.8' (101%)	27.8' in segments > 4"; (RQD=96.5)		977-968': dolomite, silty, bedded (0.5-3 inches); pores 0.06-0.25 inch are partially filled with silt; some larger vugs from 975-970' filled with silt or gypsum; few larger open vugs 975'; near-vertical fractures to 1' length, narrow apertures, some with clear gypsum fillings. 980.4-977': dolomite, fine grained, light brownish gray (2.5Y6/2); not very porous; narrow (0.01 inch), near-vertical fractures with curved planes.	

Hole ID: SNL-8 | CORE LOG (cont. sheet) | Sheet 9 of 9

Logged by: Dennis W. Powers, Ph.D. | Date: 6/25-26/05

Run Number	Depth (ft)	% Recovered	RQD	Profile (Rock Type)	Description	Remarks all times MDT
4	980–990				980.4' Base of Culebra Dolomite Member Top of Los Medaños Member M-2/H-2 982.2-980.4': Claystone, silty, dark gray (7.5YR6/0), thin laminae (<0.25 inch thick), parallel and horizontal to subhorizontal, slightly undulatory near base. Some bedding plane fibrous gypsum fills separations. 991.7' A-1 991.7-982.2': Siltstone, argillaceous reddish gray (2.5YR3/2) to reddish brown (2.5YR4/4-4/6); vague horizontal bedding; possible smeared intraclast textures. Some gray clasts, including one clast with fine laminae. Gypsum and gypsiferous zones at 982.5-982.2', 984.5', 985.3-985.2', 991.0-990.8'.	
5	1000–1010	Cored 18', recovered 19' (105.6%)	18.7' in segments > 4"; (RQD=98.4)		1000.7' M-1/H-1 1000.9-991.7': Anhydrite and gypsum, dark to medium gray, laminar to slightly wavy, poorly developed nodular textures near top. Stylolite @ 996.4'. Halite seam at 998.6". Vertical gypsum bottom-growth crystals in lower 2', increasing in size upward; some halite pseudomorphs, fine laminae between gypsum growth textures. Halite and siltstone, reddish brown, slightly sandy 1001.5-1000.9': Siltstone and halite, small fractures with halite fill; fine laminae 1002.0-1001.5': siltstone layers in halite; displacive halite at base, probable dissolution surfaces; halite becomes finer upward. 1003.2-1002.0': fine mosaic halite in siltstone, corroded margins 1005.5-1003.2': siltstone increasing upward; coarse halite with corroded margins 1006.5-1005.5': some continuous thin siltstone on exposure surfaces 1009.7-1006.5': larger siltstone masses in some areas, fewer displacive margins than lower; corroded halite margins 1013.2-1009.7': dominantly displacive halite margins in siltstone; also corroded halite margins.	
	1020–1060					

Small unidentified plant blooming next to prickly pear near SNL-8 drillpad. Photo by Dennis W. Powers.

Appendix D
Permitting and Completion Information

A case file for SNL-8 (C-3150) 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-3150.

Information on management of well-drilling wastes for SNL-8 is not included; at the time of basic data report preparation, these wastes were still being characterized for disposal.

Dennis W. Powers, Ph. D.
Consulting Geologist

June 28, 2005

Ron Richardson
Field Lead
WRES

Rick Beauheim
Hydrology Lead
Sandia National Laboratories

Re: Screen Interval for Culebra Dolomite Member in SNL-8

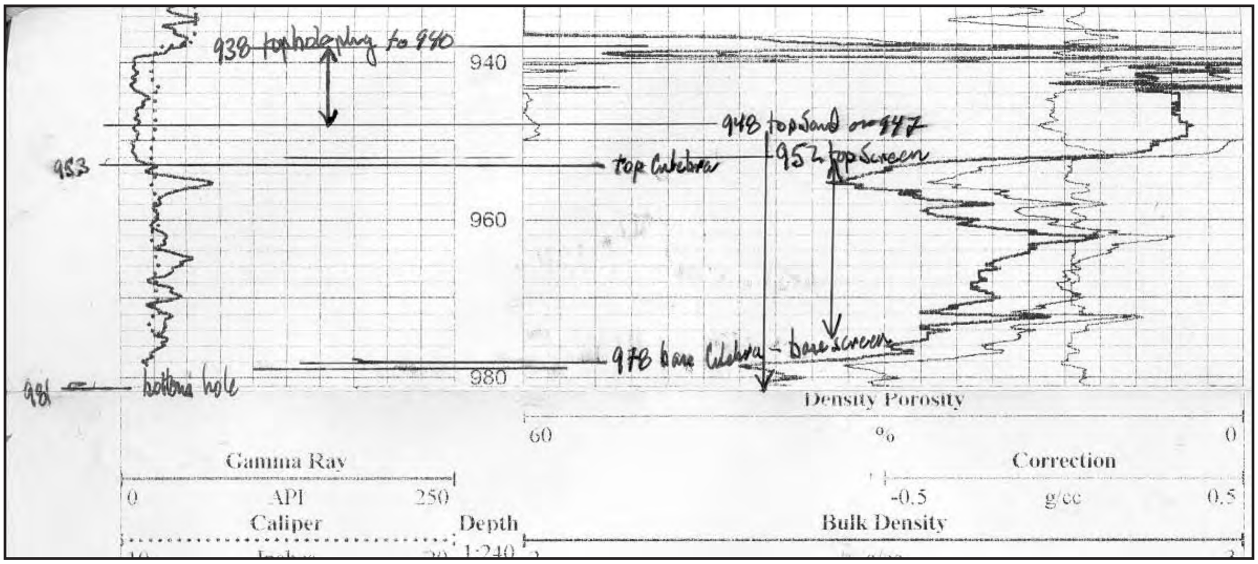
The information regarding the Culebra Dolomite Member in SNL-8 indicates that the best interval to screen is from about 952–978 ft below the top of the surface conductor casing (~drilling pad level). This decision is based on geophysical logs completed on June 28, 2005 (see attached figure) and cores from SNL-8.

These are factors considered in this decision for SNL-8:

- The Culebra interval, based on the natural gamma geophysical log and density log, is from 953–978 ft. This interval is 25 ft thick, about average around the WIPP site. Coring indicated 26 ft of Culebra, with excellent recovery, and the base of Culebra is expected to actually be at 979 ft, given that fill in the drillhole at 981 ft limited the geophysical logs.
- Core across the transition from Culebra to Los Medaños was recovered intact. The gray silty claystone below the Culebra was more indurated and less plastic than in some drillholes. It showed well developed layering and no significant deformation. The base of the screen at 978 ft will be at or near the base of the Culebra. If the casing can be placed to 981 ft, the base of the screen will be at 979 ft. Given the physical characteristics of the siltly claystone at the top of the Los Medaños Member, there should not be a problem with squeezing of the claystone into the screen.
- The screened or slotted section of the casing joint is 26.1 ft long and begins 1.9 ft above the endcap. This will provide a screened interval that may incorporate all of the Culebra if the top of fill remains at 981 ft. The top of the screened interval will be at 953 ft if the fill is at 981 ft.
- The laminated claystone and mudstone (M-2/H-2) below the Culebra was well sampled. No salt was detected in this section, and fill through this section is acceptable.
- Cores below A-1 sampled halite to the final cored depth of 1013.2 ft. Seven bags of HolePlug® were loaded into the drillhole as soon as the core barrel was removed. This is the equivalent of 21 ft of hole fill, to bring the plugged section up to an estimated 994 ft, which is above Anhydrite 1 and in M-2 below the Culebra. The drillhole was reamed to 995 ft, above halite, and the HolePlug® provides a seal to circulation below the casing to the halitic section.cemented back, and the top of cement was tagged at 679 ft, which is just below the Culebra. This uppermost cement will be drilled out when the well is reamed for casing. SNL-8 should be reamed to a depth of ~684–686 ft, a maximum of 2 ft into the anhydrite (A-1) below the Culebra.
- Geophysical logs and core above the Culebra indicate the anhydrite/gypsum unit (A-2) is intact and separates the Culebra from the Tamarisk Member mudstone (M-3) by 14 ft. The base of M-3 is at 636 ft. There is a thin siltstone in the upper part of A-2 (638-639.5 ft on logs) that should also be isolated from the Culebra screen interval.
- The sand/gravel pack should be placed from the base of the reamed drillhole to a depth of about 645 ft, just above the upper screen. The bentonite seal will be placed from about 645 to about 640 ft, and the annulus will be cemented from the top of the HolePlug® ft to the surface. This should prevent circulation into the Tamarisk mudstone (M-3).

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

Note (6/18/2008): the figure distributed with the original completion letter (previous page) was not prepared for drillhole SNL-8 and was therefore incorrect. The completion was based on field information consistent with the text (previous page) as shown in the scanned copy of the field diagram (below).



Dennis W. Powers, Ph. D.
Consulting Geologist

August 23, 2005

Rey Carrasco
Geotechnical Engineering
Washington TRU Solutions
Carlsbad, NM 88220

Storage and Retention of Cores and Rock Samples from SNL-8

Background
Cores and cutting samples have been collected from drillhole SNL-8 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-8 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-8 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-8 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 <u>cores</u> obtained from SNL-8 be maintained indefinitely under normal storage conditions because of their relevance to hydrology and monitoring programs. The <u>cores</u> 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 <u>cuttings</u> samples be retained under normal storage conditions through the approval by EPA of the second CRA. The <u>cuttings</u> are commonly very fine in shallow sections and add little to the geologic record from initial observations as well as geophysical logs. <u>Cuttings</u> 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-8.

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*

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

COPY

Roswell Office
1900 WEST SECOND STREET
ROSWELL, NM 88201

STATE OF NEW MEXICO
OFFICE OF THE STATE ENGINEER

Trn Nbr: 323370
File Nbr: C 3150

February 10, 2005

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

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
Mike Stapleton
(505)622-6467

Enclosure

cc: Santa Fe Office

explore

UNIQUE #	DOE UFC	DATE REC'VD	ADDRESSEES
5W609	5480.00	FEB 14 2005	H Johnson eforms wh.

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 03150 must be completed and the Well Log filed on or before 02/28/2006.

ACTION OF STATE ENGINEER

Notice of Intention Rcvd:
Formal Application Rcvd: 02/07/2005
Date Returned - Correction:

Date Rcvd. Corrected:
Pub. of Notice Ordered:
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 3150 MONITORING WELL

File Number: C 03150
Trn Number: 323370

page: 1

SNL 8
Revised August 1

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 02-05-07 File No. C-3150

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 ne 1/4 se 1/4 se 1/4 Section 14 Township 22 South Range 31 East N.M.P.M., or Tract No. n/a of Map No. n/a of the Carlsbad, 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 1276 then plugged back to 1000 feet

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

2005 FEB -7 PM 1:52

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 Feb day of 7th A.D., 2005

My commission expires Oct. 3, 2005 Sharon Warren-Briggs
Notary Public
#323370

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 n exercised to the detriment of any others having existing rights; further provided that all rules and regulati the State Engineer pertaining to the drilling of____________ wells be complied with; and further subje the following conditions:______________________________________

see attached conditions of approval

Proof of completion of well shall be filed on or before________N/A________XX

Proof of application of water to beneficial use shall be filed on or before________N/A________XX

Witness my hand and seal this ______10th______ day of______February______, A.D., 2

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

By:______________________________

Art Mason, District II Supervisor

INSTRUCTIONS

This form shall be executed, preferably typewritten, in triplicate and shall be accompanied by a filing fee of $25. 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 us 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 loca 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.

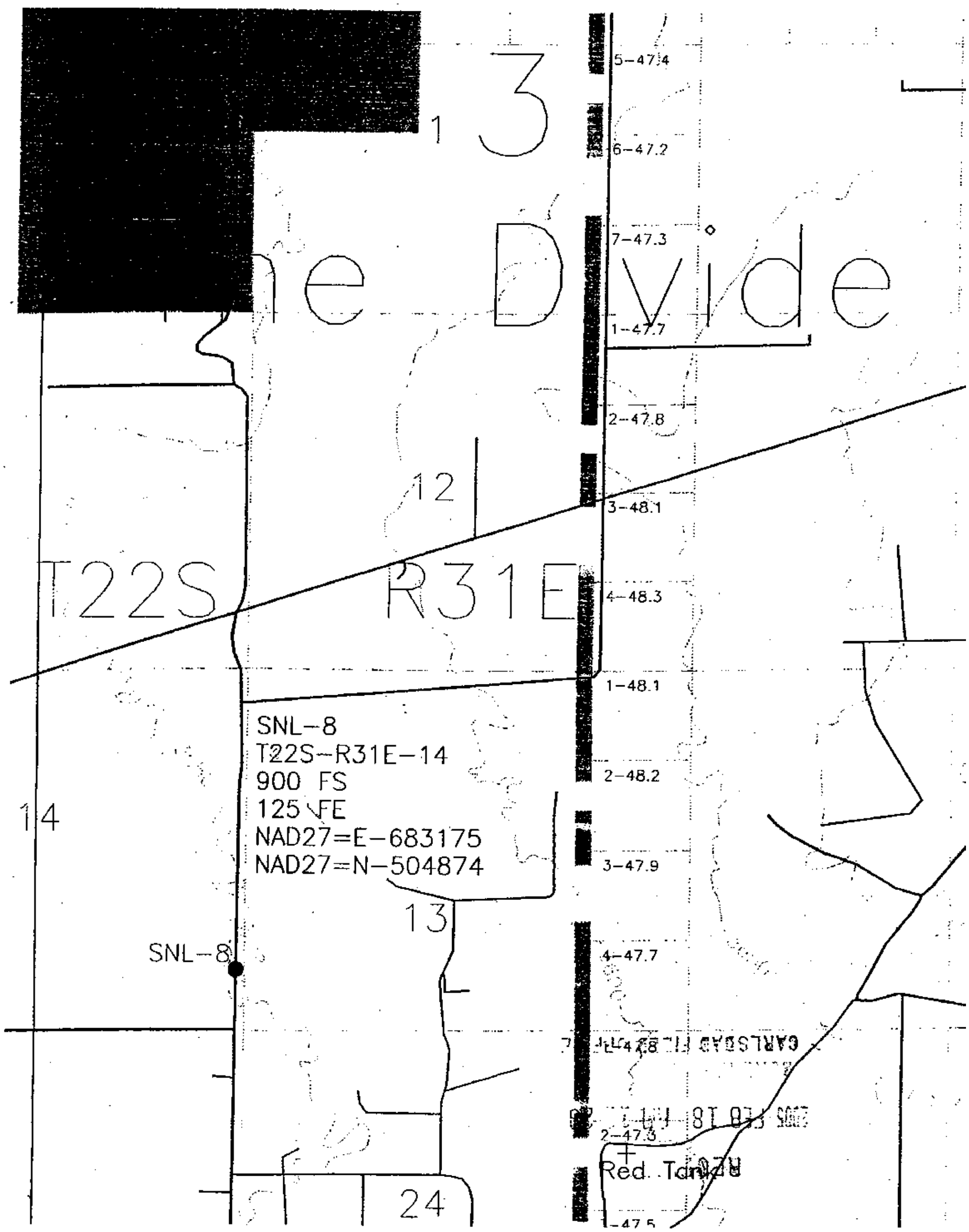
D. Attached are Special Stipulations for Site Reclamation.

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


3
12
T22S
R31E
SNL-8
T22S-R31E-14
900 FS
125 FE
NAD27=E-683175
NAD27=N-504874
13
14
24
SNL-8
5-47.4
6-47.2
7-47.3
1-47.7
2-47.8
3-48.1
4-48.3
1-48.1
2-48.2
3-47.9
4-47.7
2-47.3
Red. Tank

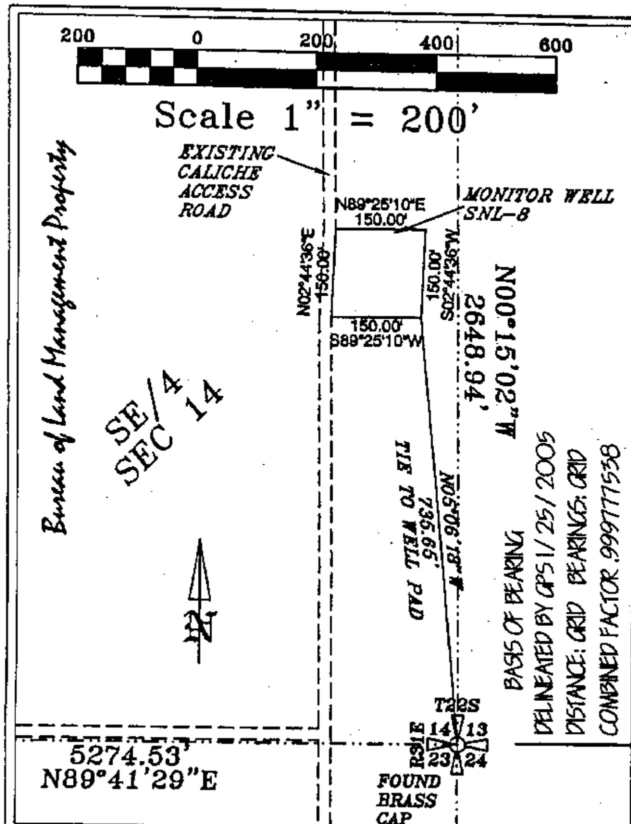


EXHIBIT A

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 N05°06'18"W 735.65' FROM THE SE CORNER OF SEC 14, T22S, R31E, N.M.P.M., EDDY COUNTY, NEW MEXICO; THEN S89°25'10"W FOR 150.00'; THEN N02°44'36"E FOR 150.00'; THEN N89°25'10"E FOR 150.00'; THEN S02°44'36"W FOR 150.00' TO THE POINT OF BEGINNING.

LEGEND

- LAND LINE
- SECTION CORNER
- EXISTING DIRT ROAD ACCESS

THE NEW MEXICO STATE PLANE EAST NAD27 COORDINATES FOR WELL SNL-8
504841.34 N*
683175.74 E*
ELEV-3552.75*
(*SUBJECT TO CHANGE)

MELVIN R. PYEATT
NEW MEXICO
8510
REGISTERED PROFESSIONAL LAND SURVEYOR

WELL INFORMATION	
NUMBER	SNL-8
IN SEC. 14	T 22S R 31E
COUNTY:	EDDY
STATE:	NEW MEXICO
DATE:	FEBRUARY 3, 2005

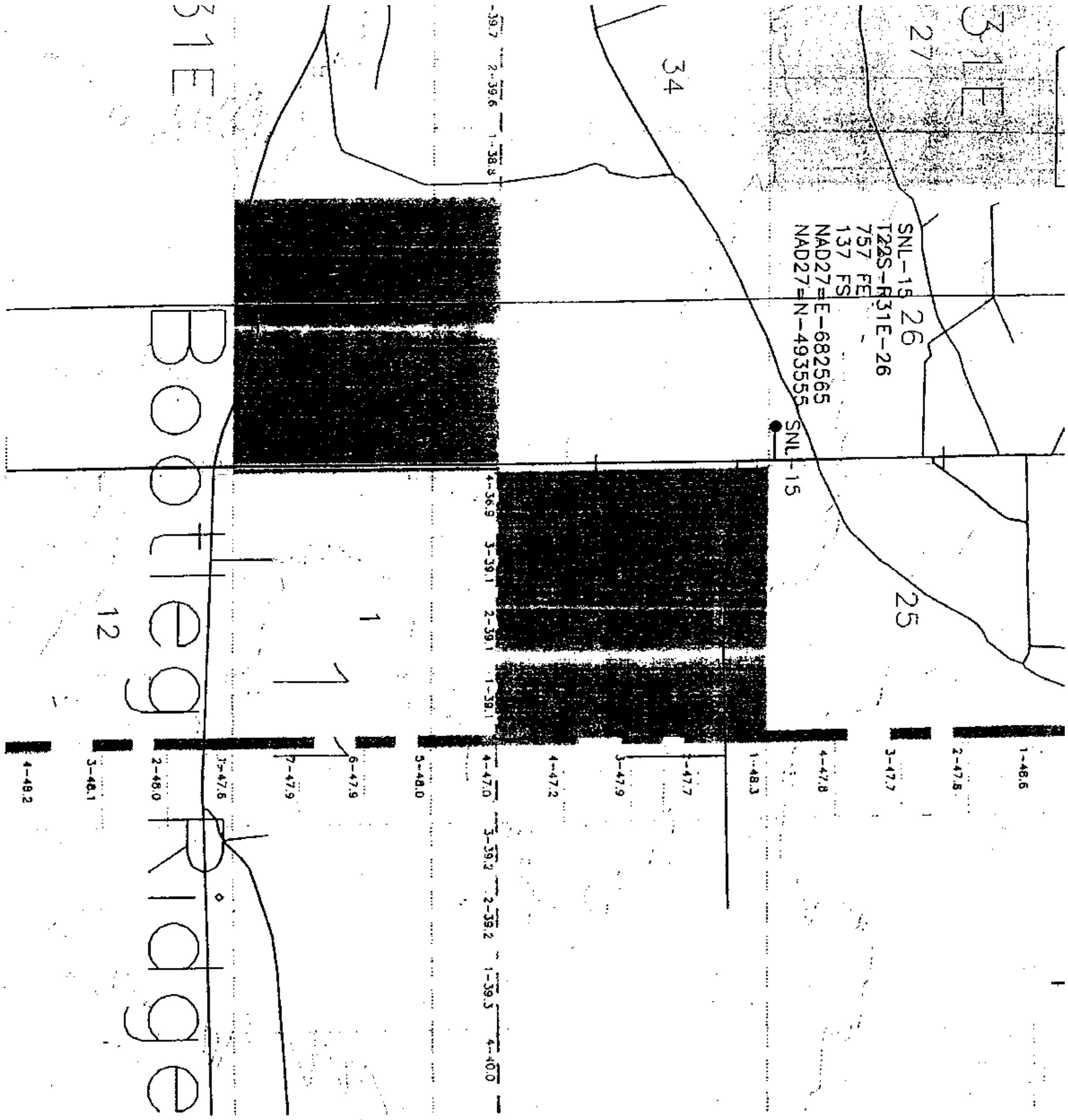

SNL-15
T22S-R31E-26
757 FE
137 FS
NAD27=E-682565
NAD27=N-493555
SNL-15
Bootleg Ridge
31E
34
26
27
25
12
1

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 <u>Shale Green</u>, Munsell Soil Color Chart Number <u>5Y 4/2</u>.

NM-108365
March 15, 2005
Page 2 of 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

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.

STATE ENGINEER OFFICE

WELL RECORD

Section 1. GENERAL INFORMATION

(A) Owner of well WASHINGTON TRU SOLUTIONS Owner's Well No. SNL-8
Street or Post Office Address P.O. BOX 2078
City and State CARLSBAD, NEW MEXICO 88221

Well was drilled under Permit No. C3150 and is located in the:

a. SE ¼ SE ¼ ____ ¼ ____ ¼ of Section 14 Township 22 S Range 31 E N.M.P.M.

b. Tract No. N/A of Map No. N/A of the CARLSBAD DISTRICT

c. Lot No. ____ of Block No. ____ of the ____
Subdivision, recorded in EDDY 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 6-13-05 Completed 6-28-05 Type tools AIR ROTARY Size of hole 11 in.

Elevation of land surface or ____ at well is 3553 ft. Total depth of well 981 ft.

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

Section 2. PRINCIPAL WATER-BEARING STRATA

Depth in Feet		Thickness in Feet	Description of Water-Bearing Formation	Estimated Yield (gallons per minute)
From	To			
953	979	26	BROWN DOLOMITE CULEBRA FORMATION	

Section 3. RECORD OF CASING

Diameter (inches)	Pounds per foot	Threads per in.	Depth in Feet		Length (feet)	Type of Shoe	Perforations	
			Top	Bottom			From	To
12-3/4	33.41	WELDED	3' AGL	37	40			
5-1/2 FIBERGLASS	4.4	4	2-1/2' AGL	981	983-1/2	FIBERGLASS CAP	952	010 SCREEN 978

Section 4. RECORD OF MUDDING AND CEMENTING

Depth in Feet		Hole Diameter	Sacks of Mud	Cubic Feet of Cement	Method of Placement
From	To				
0	37	17-1/2		30	TRIMMIE
0	938	11" 5-1/2 CASING		513	TRIMMIE
1013	991	6-3/4	HOLE PLUG 7 BAGS		

Section 5. PLUGGING RECORD

Plugging Contractor ____
Address ____
Plugging Method ____
Date Well Plugged ____
Plugging approved by:

____
State Engineer Representative

No.	Depth in Feet		Cubic Feet of Cement
	Top	Bottom	
1			
2			
3			
4			

FOR USE OF STATE ENGINEER ONLY

Date Received

Quad ____ FWL ____ FSL ____

File No. ____ Use ____ Location No. ____

Depth in Feet		Thickness in Feet	Color and Type of Material Encountered
From	To		
0	10	10	CONSTRUCTION FILL & DUNE SAND
10	20	10	WHITE CALICHE & CALCAREOUS SAND (SANTA ROSA)
20	262	242	WEAK RED SANDSTONE & LAMINATED CLAYSTONE (TRIASSIC SANTA ROSA FORMATION)
262	780	518	RED TO REDDISH BROWN SANDY SILTSTON, SILTY CLAYSTONE & FINE SANDSTON (PERMOTRIASSIC DEWEY LAKE FORMATION)
780	838	58	GRAY ANHYDRITE BEDS WITH INTERMEDIATE HALITE & REDDISH BROWN ARGILLACEOUS HALITE (FORTY-NINER MEMBER OF RUSTLER FORMATION)
837	864	27	LIGHT OLIVE GRAY GYPSIFEROUS DOLOMITE (MAGENTA DOLOMITE MEMBER OF RUSTLER FORMATION)
864	953	89	GRAY ANHYDRITE & GYPSUM BEDS WITH INTERMEDIATE GRAY TO REDDISH BROWN SILTY CLAYSTONE (TAMARISK MEMBER OF THE RUSTLER FORMATION)
953	979	26	BROWN DOLOMITE WITH GYPSUM NODULES, SILTY PORE FILLINGS, & SLIGHT FRACTURING (CULEBRA DOLOMITE MEMBER OF THE RUSTLER FORMATION)
979	992	13	DARK GRAY GYPSIFEROUS CLAYSTONE & SILTSTONE (UPPERMOST LOS MEDANOS MEMBER OF THE RUSTLER FORMATION)
992	1001	9	LIGHT GRAY ANHYDRITE & WHITE GYPSUM WITH THIN HALITE BED IN LOWER PART (ANHYDRITE 1 OF LOSE MEDANOS MEMBER OF RUSTLER FORM)
1001	1013.2	12.2	CLEAR, COARSE HALITE & REDDISH BROWN ARGILLACEOUS TO SILTY AHLITE (UPPER LOS MEDANOS MEMBER OF THE RUSTLER FORMATION)

Section 7. REMARKS AND ADDITIONAL INFORMATION

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.

Unidentified shrub near drill pad at SNL-8. Photo by Dennis W. Powers.

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 **Author(s):** Theresa Straight	**6. Fieldwork Date(s):** February 2, 2005 **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.

Survey for the SNL-6, SNL-8, and SNL-15 Well Pads

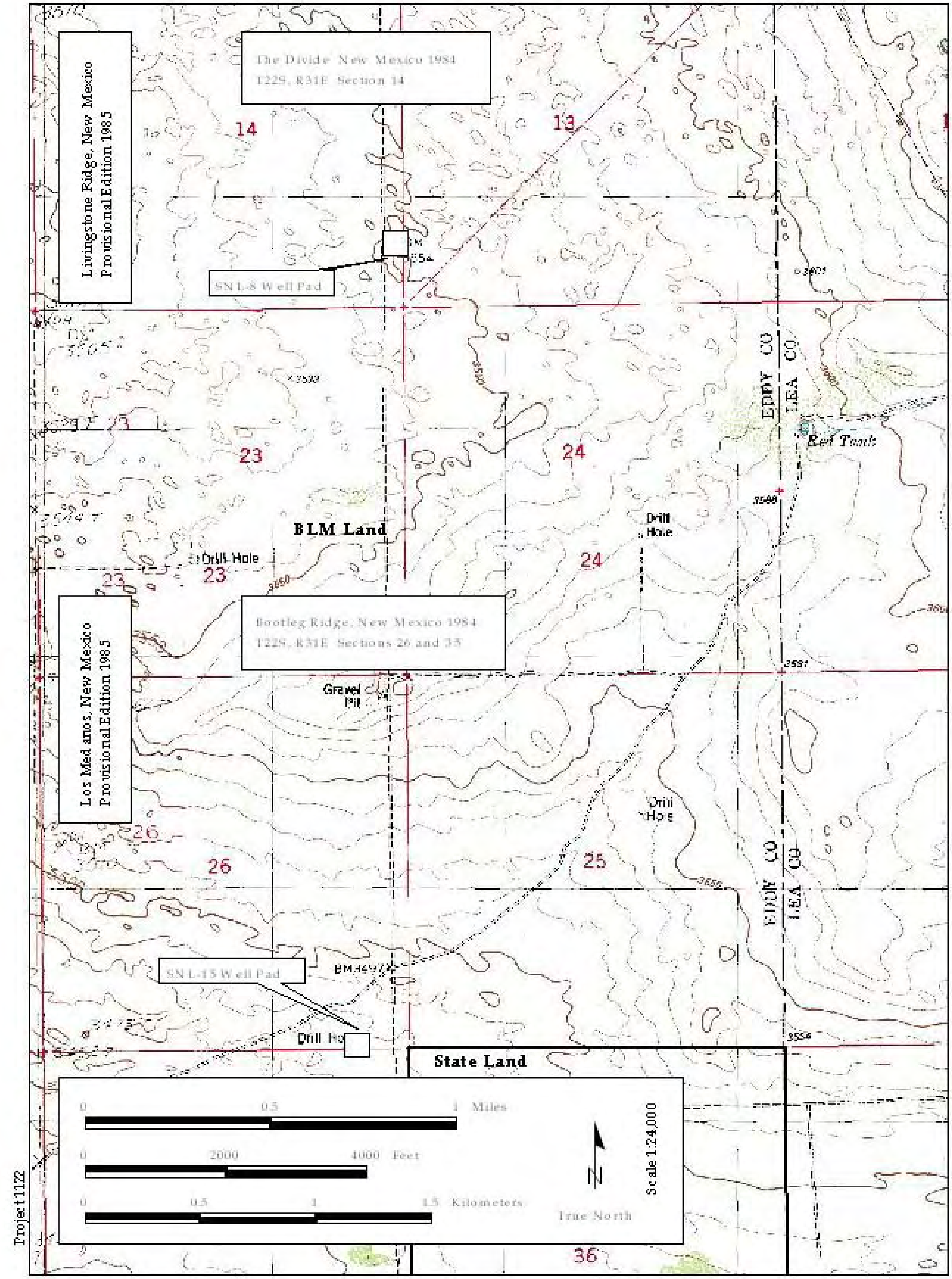


Figure 1. Project Area Map *Mesa Field Services*

Appendix F
Photograph Logs

Digital photographs were taken of the cores from SNL-8. These photographs have been compiled into a listing of consecutive photos beginning with the uppermost core (Magenta Dolomite 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.

File	DATE	LOCATION	**DESCRIPTION OF SUBJECT** (includes individual/group names, direction, etc. as appropriate)	**PHOTOGRAPHER** (initials and dept.)
SNL-8_Core001.jpg	6/24/05	SNL-8 drillpad; T22S, R31E, sec 14	Close-up photo of Forty-niner Mbr core, 836.0 - 837.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-8_Core002.jpg	6/24/05	SNL-8 drillpad; T22S, R31E, sec 14	Close-up photo of Forty-niner/Magenta Dolomite Mbrs core, 836.9 - 838.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-8_Core003.jpg	6/24/05	SNL-8 drillpad; T22S, R31E, sec 14	Close-up photo of Magenta Dolomite Mbr core, 837.9 - 839.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-8_Core004.jpg	6/24/05	SNL-8 drillpad; T22S, R31E, sec 14	Close-up photo of Magenta Dolomite Mbr core, 838.9 - 840.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-8_Core005.jpg	6/24/05	SNL-8 drillpad; T22S, R31E, sec 14	Close-up photo of Magenta Dolomite Mbr core, 839.9 - 841.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-8_Core006.jpg	6/24/05	SNL-8 drillpad; T22S, R31E, sec 14	Close-up photo of Magenta Dolomite Mbr core, 840.9 - 842.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-8_Core007.jpg	6/24/05	SNL-8 drillpad; T22S, R31E, sec 14	Close-up photo of Magenta Dolomite Mbr core, 841.9 - 843.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-8_Core008.jpg	6/24/05	SNL-8 drillpad; T22S, R31E, sec 14	Close-up photo of Magenta Dolomite Mbr core, 842.9 - 844.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-8_Core009.jpg	6/24/05	SNL-8 drillpad; T22S, R31E, sec 14	Close-up photo of Magenta Dolomite Mbr core, 843.9 - 845.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-8_Core010.jpg	6/24/05	SNL-8 drillpad; T22S, R31E, sec 14	Close-up photo of Magenta Dolomite Mbr core, 844.9 - 846.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-8_Core011.jpg	6/24/05	SNL-8 drillpad; T22S, R31E, sec 14	Close-up photo of Magenta Dolomite Mbr core, 845.9 - 847.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-8_Core012.jpg	6/24/05	SNL-8 drillpad; T22S, R31E, sec 14	Close-up photo of Magenta Dolomite Mbr core, 846.9 - 848.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-8_Core013.jpg	6/24/05	SNL-8 drillpad; T22S, R31E, sec 14	Close-up photo of Magenta Dolomite Mbr core, 847.9 - 849.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-8_Core014.jpg	6/24/05	SNL-8 drillpad; T22S, R31E, sec 14	Close-up photo of Magenta Dolomite Mbr core, 848.9 - 850.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-8_Core015.jpg	6/24/05	SNL-8 drillpad; T22S, R31E, sec 14	Close-up photo of Magenta Dolomite Mbr core, 849.8 - 851.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-8_Core016.jpg	6/24/05	SNL-8 drillpad; T22S, R31E, sec 14	Close-up photo of Magenta Dolomite Mbr core, 850.9 - 852.1 ft bgl, with markings, scale	DW Powers Consultant to WTS

Camera: Nikon CoolPix 5700 **Resolution**: 2560 x 1920 **Page** X of Y

File	DATE	LOCATION	DESCRIPTION OF SUBJECT (includes individual/group names, direction, etc. as appropriate)	PHOTOGRAPHER (initials and dept.)
SNL-8_Core017.jpg	6/24/05	SNL-8 drillpad; T22S, R31E, sec 14	Close-up photo of Magenta Dolomite Mbr core, 851.9 - 852.7 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-8_Core018.jpg	6/24/05	SNL-8 drillpad; T22S, R31E, sec 14	Close-up photo of Magenta Dolomite Mbr core, 852.7 - 853.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-8_Core019.jpg	6/24/05	SNL-8 drillpad; T22S, R31E, sec 14	Close-up photo of Magenta Dolomite Mbr core, 852.8 - 854.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-8_Core020.jpg	6/24/05	SNL-8 drillpad; T22S, R31E, sec 14	Close-up photo of Magenta Dolomite Mbr core, 853.8 - 855.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-8_Core021.jpg	6/24/05	SNL-8 drillpad; T22S, R31E, sec 14	Close-up photo of Magenta Dolomite Mbr core, 854.8 - 856.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-8_Core022.jpg	6/24/05	SNL-8 drillpad; T22S, R31E, sec 14	Close-up photo of Magenta Dolomite Mbr core, 855.8 - 857.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-8_Core023.jpg	6/24/05	SNL-8 drillpad; T22S, R31E, sec 14	Close-up photo of Magenta Dolomite Mbr core, 856.8 - 858.2 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-8_Core024.jpg	6/24/05	SNL-8 drillpad; T22S, R31E, sec 14	Close-up photo of Magenta Dolomite Mbr core, 857.8 - 859.2 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-8_Core025.jpg	6/24/05	SNL-8 drillpad; T22S, R31E, sec 14	Close-up photo of Magenta Dolomite Mbr core, 858.7 - 860.3 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-8_Core026.jpg	6/24/05	SNL-8 drillpad; T22S, R31E, sec 14	Close-up photo of Magenta Dolomite Mbr core, 859.8 - 861.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-8_Core027.jpg	6/24/05	SNL-8 drillpad; T22S, R31E, sec 14	Close-up photo of Magenta Dolomite Mbr core, 860.8 - 862.2 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-8_Core028.jpg	6/24/05	SNL-8 drillpad; T22S, R31E, sec 14	Close-up photo of Magenta Dolomite Mbr core, 861.8 - 863.2 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-8_Core029.jpg	6/24/05	SNL-8 drillpad; T22S, R31E, sec 14	Close-up photo of Magenta Dolomite Mbr core, 862.8 - 864.2 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-8_Core030.jpg	6/24/05	SNL-8 drillpad; T22S, R31E, sec 14	Close-up photo of Magenta Dolomite/ Tamarisk Mbr core, 863.8 - 865.2 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-8_Core031.jpg	6/24/05	SNL-8 drillpad; T22S, R31E, sec 14	Close-up photo of Tamarisk Mbr core, 864.9 - 866.2 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-8_Core032.jpg	6/25/05	SNL-8 drillpad; T22S, R31E, sec 14	Close-up photo of Tamarisk Mbr core, 920.0 - 921.2 ft bgl, with markings, scale	DW Powers Consultant to WTS

Camera: Nikon CoolPix 5700 **Resolution**: 2560 x 1920 **Page** X of Y

File	DATE	LOCATION	DESCRIPTION OF SUBJECT (includes individual/group names, direction, etc. as appropriate)	PHOTOGRAPHER (initials and dept.)
SNL-8_Core033.jpg	6/25/05	SNL-8 drillpad; T22S, R31E, sec 14	Close-up photo of Tamarisk Mbr core, 921.0 - 922.2 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-8_Core034.jpg	6/25/05	SNL-8 drillpad; T22S, R31E, sec 14	Close-up photo of Tamarisk Mbr core, 922.0 - 923.2 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-8_Core035.jpg	6/25/05	SNL-8 drillpad; T22S, R31E, sec 14	Close-up photo of Tamarisk Mbr core, 923.0 - 924.2 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-8_Core036.jpg	6/25/05	SNL-8 drillpad; T22S, R31E, sec 14	Close-up photo of Tamarisk Mbr core, 923.9 - 925.2 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-8_Core037.jpg	6/25/05	SNL-8 drillpad; T22S, R31E, sec 14	Close-up photo of Tamarisk Mbr core, 925.0 - 926.2 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-8_Core038.jpg	6/25/05	SNL-8 drillpad; T22S, R31E, sec 14	Close-up photo of Tamarisk Mbr core, 925.9 - 927.2 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-8_Core039.jpg	6/25/05	SNL-8 drillpad; T22S, R31E, sec 14	Close-up photo of Tamarisk Mbr core, 926.9 - 928.2 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-8_Core040.jpg	6/25/05	SNL-8 drillpad; T22S, R31E, sec 14	Close-up photo of Tamarisk Mbr core, 927.9 - 929.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-8_Core041.jpg	6/25/05	SNL-8 drillpad; T22S, R31E, sec 14	Close-up photo of Tamarisk Mbr core, 928.9 - 930.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-8_Core042.jpg	6/25/05	SNL-8 drillpad; T22S, R31E, sec 14	Close-up photo of Tamarisk Mbr core, 930.0 - 931.2 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-8_Core043.jpg	6/25/05	SNL-8 drillpad; T22S, R31E, sec 14	Close-up photo of Tamarisk Mbr core, 930.9 - 932.2 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-8_Core044.jpg	6/25/05	SNL-8 drillpad; T22S, R31E, sec 14	Close-up photo of Tamarisk Mbr core, 932.0 - 933.2 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-8_Core045.jpg	6/25/05	SNL-8 drillpad; T22S, R31E, sec 14	Close-up photo of Tamarisk Mbr core, 933.0 - 934.2 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-8_Core046.jpg	6/25/05	SNL-8 drillpad; T22S, R31E, sec 14	Close-up photo of Tamarisk Mbr core, 934.0 - 934.4 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-8_Core047.jpg	6/26/05	SNL-8 drillpad; T22S, R31E, sec 14	Close-up photo of Tamarisk Mbr core, 935.4-936.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-8_Core048.jpg	6/26/05	SNL-8 drillpad; T22S, R31E, sec 14	Close-up photo of Tamarisk Mbr core, 935.9 - 937.1 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-8_Core049.jpg	6-26-05	SNL-8 drillpad; T22S, R31E, sec 14	Close-up photo of Tamarisk Mbr core, 936.9 - 938.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-8_Core050.jpg	6-26-05	SNL-8 drillpad; T22S, R31E, sec 14	Close-up photo of Tamarisk Mbr core, 937.8 - 939.0 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-8_Core051.jpg	6-26-05	SNL-8 drillpad; T22S, R31E, sec 14	Close-up photo of Tamarisk Mbr core, 938.9 - 940.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-8_Core052.jpg	6-26-05	SNL-8 drillpad; T22S, R31E, sec 14	Close-up photo of Tamarisk Mbr core, 939.8 - 941.0 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-8_Core053.jpg	6-26-05	SNL-8 drillpad; T22S, R31E, sec 14	Close-up photo of Tamarisk Mbr core, 940.8 - 942.0 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-8_Core054.jpg	6-26-05	SNL-8 drillpad; T22S, R31E, sec 14	Close-up photo of Tamarisk Mbr core, 941.9 - 943.9 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-8_Core055.jpg	6-26-05	SNL-8 drillpad; T22S, R31E, sec 14	Close-up photo of Tamarisk Mbr core, 942.9 - 944.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-8_Core056.jpg	6-26-05	SNL-8 drillpad; T22S, R31E, sec 14	Close-up photo of Tamarisk Mbr core, 943.9 - 945.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-8_Core057.jpg	6-26-05	SNL-8 drillpad; T22S, R31E, sec 14	Close-up photo of Tamarisk Mbr core, 944.8 - 946.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-8_Core058.jpg	6-26-05	SNL-8 drillpad; T22S, R31E, sec 14	Close-up photo of Tamarisk Mbr core, 945.9 - 947.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-8_Core059.jpg	6-26-05	SNL-8 drillpad; T22S, R31E, sec 14	Close-up photo of Tamarisk Mbr core, 946.8 - 948.0 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-8_Core060.jpg	6-26-05	SNL-8 drillpad; T22S, R31E, sec 14	Close-up photo of Tamarisk Mbr core, 967.9 - 949.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-8_Core061.jpg	6-26-05	SNL-8 drillpad; T22S, R31E, sec 14	Close-up photo of Tamarisk Mbr core, 948.8 - 950.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-8_Core062.jpg	6-26-05	SNL-8 drillpad; T22S, R31E, sec 14	Close-up photo of Tamarisk Mbr core, 949.8 - 951.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-8_Core063.jpg	6-26-05	SNL-8 drillpad; T22S, R31E, sec 14	Close-up photo of Tamarisk Mbr core, 950.8 - 952.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-8_Core064.jpg	6-26-05	SNL-8 drillpad; T22S, R31E, sec 14	Close-up photo of Tamarisk Mbr core, 951.8 - 953.0 ft bgl, with markings, scale	DW Powers Consultant to WTS

Camera: Nikon CoolPix 5700 **Resolution**: 2560 x 1920 **Page** X of Y

File	DATE	LOCATION	DESCRIPTION OF SUBJECT (includes individual/group names, direction, etc. as appropriate)	PHOTOGRAPHER (initials and dept.)
SNL-8_Core065.jpg	6-26-05	SNL-8 drillpad; T22S, R31E, sec 14	Close-up photo of Tamarisk Mbr core, 953.0 - 954.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-8_Core066.jpg	6-26-05	SNL-8 drillpad; T22S, R31E, sec 14	Close-up photo of Tamarisk and Culebra Dolomite Mbr core, 953.9 - 955.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-8_Core067.jpg	6-26-05	SNL-8 drillpad; T22S, R31E, sec 14	Close-up photo of Tamarisk and Culebra Dolomite Mbr core, 954.9 - 956.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-8_Core068.jpg	6-26-05	SNL-8 drillpad; T22S, R31E, sec 14	Close-up photo of Culebra Dolomite Mbr core, 955.9 - 957.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-8_Core069.jpg	6-26-05	SNL-8 drillpad; T22S, R31E, sec 14	Close-up photo of Culebra Dolomite Mbr core, 956.9 - 958.1 ft bgl, with scale	DW Powers Consultant to WTS
SNL-8_Core070.jpg	6-26-05	SNL-8 drillpad; T22S, R31E, sec 14	Close-up photo of Culebra Dolomite Mbr core, 959.9 - 959.2 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-8_Core071.jpg	6-26-05	SNL-8 drillpad; T22S, R31E, sec 14	Close-up photo of Culebra Dolomite Mbr core, 958.9 - 960.2 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-8_Core072.jpg	6-26-05	SNL-8 drillpad; T22S, R31E, sec 14	Close-up photo of Culebra Dolomite Mbr core, 959.9 - 961.2 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-8_Core073.jpg	6-26-05	SNL-8 drillpad; T22S, R31E, sec 14	Close-up photo of Culebra Dolomite Mbr core, 960.9 - 962.2 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-8_Core074.jpg	6-26-05	SNL-8 drillpad; T22S, R31E, sec 14	Close-up photo of Culebra Dolomite Mbr core, 961.9 - 963.2 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-8_Core075.jpg	6-26-05	SNL-8 drillpad; T22S, R31E, sec 14	Close-up photo of Culebra Dolomite Mbr core, 962.9 - 964.2 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-8_Core076.jpg	6-26-05	SNL-8 drillpad; T22S, R31E, sec 14	Close-up photo of Culebra Dolomite Mbr core, 963.9 - 965.2 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-8_Core077.jpg	6-26-05	SNL-8 drillpad; T22S, R31E, sec 14	Close-up photo of Culebra Dolomite Mbr core, 964.7 - 965.6 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-8_Core078.jpg	6-26-05	SNL-8 drillpad; T22S, R31E, sec 14	Close-up photo of Culebra Dolomite Mbr core, 965.6 - 966.2 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-8_Core079.jpg	6-26-05	SNL-8 drillpad; T22S, R31E, sec 14	Close-up photo of Culebra Dolomite Mbr core, 966.1 - 967.2 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-8_Core080.jpg	6-26-05	SNL-8 drillpad; T22S, R31E, sec 14	Close-up photo of Culebra Dolomite Mbr core, 967.1 - 968.2 ft bgl, with markings, scale	DW Powers Consultant to WTS

Camera: Nikon CoolPix 5700 **Resolution**: 2560 x 1920 **Page** X of Y

File	DATE	LOCATION	DESCRIPTION OF SUBJECT (includes individual/group names, direction, etc. as appropriate)	PHOTOGRAPHER (initials and dept.)
SNL-8_Core081.jpg	6-26-05	SNL-8 drillpad; T22S, R31E, sec 14	Close-up photo of Culebra Dolomite Mbr core, 967.0 - 968.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-8_Core082.jpg	6-26-05	SNL-8 drillpad; T22S, R31E, sec 14	Close-up photo of Culebra Dolomite Mbr core, 968.0 -969.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-8_Core083.jpg	6-26-05	SNL-8 drillpad; T22S, R31E, sec 14	Close-up photo of Culebra Dolomite Mbr core, 968.9 - 970.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-8_Core084.jpg	6-26-05	SNL-8 drillpad; T22S, R31E, sec 14	Close-up photo of Culebra Dolomite Mbr core, 969.9 - 971.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-8_Core085.jpg	6-26-05	SNL-8 drillpad; T22S, R31E, sec 14	Close-up photo of Culebra Dolomite Mbr core, 971.0 - 972.2 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-8_Core086.jpg	6-26-05	SNL-8 drillpad; T22S, R31E, sec 14	Close-up photo of Culebra Dolomite Mbr core, 971.9 - 973.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-8_Core087.jpg	6-26-05	SNL-8 drillpad; T22S, R31E, sec 14	Close-up photo of Culebra Dolomite Mbr core, 972.9 - 974.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-8_Core088.jpg	6-26-05	SNL-8 drillpad; T22S, R31E, sec 14	Close-up photo of Culebra Dolomite Mbr core, 973.9 - 975.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-8_Core089.jpg	6-26-05	SNL-8 drillpad; T22S, R31E, sec 14	Close-up photo of Culebra Dolomite Mbr core, 974.9 - 976.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-8_Core090.jpg	6-26-05	SNL-8 drillpad; T22S, R31E, sec 14	Close-up photo of Culebra Dolomite Mbr core, 975.9 - 977.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-8_Core091.jpg	6-26-05	SNL-8 drillpad; T22S, R31E, sec 14	Close-up photo of Culebra Dolomite Mbr core, 976.9 - 978.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-8_Core092.jpg	6-26-05	SNL-8 drillpad; T22S, R31E, sec 14	Close-up photo of Culebra Dolomite Mbr core, 977.9 - 979.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-8_Core093.jpg	6-26-05	SNL-8 drillpad; T22S, R31E, sec 14	Close-up photo of Culebra Dolomite Mbr core, 978.9 - 980.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-8_Core094.jpg	6-26-05	SNL-8 drillpad; T22S, R31E, sec 14	Close-up photo of Culebra Dolomite/Los Medaños Mbr core, 979.9 - 980.4 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-8_Core095.jpg	6-26-05	SNL-8 drillpad; T22S, R31E, sec 14	Close-up photo of Los Medaños Mbr core, 980.4 - 981.2 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-8_Core096.jpg	6-26-05	SNL-8 drillpad; T22S, R31E, sec 14	Close-up photo of Los Medaños Mbr core, 980.9 - 982.2 ft bgl, with markings, scale	DW Powers Consultant to WTS

Camera: Nikon CoolPix 5700 **Resolution**: 2560 x 1920 **Page** X of Y

File	DATE	LOCATION	DESCRIPTION OF SUBJECT (includes individual/group names, direction, etc. as appropriate)	PHOTOGRAPHER (initials and dept.)
SNL-8_Core097.jpg	6-26-05	SNL-8 drillpad; T22S, R31E, sec 14	Close-up photo of Los Medaños Mbr core, 981.9 - 983.2 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-8_Core098.jpg	6-26-05	SNL-8 drillpad; T22S, R31E, sec 14	Close-up photo of Los Medaños Mbr core, 982.9 - 984.2 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-8_Core099.jpg	6-26-05	SNL-8 drillpad; T22S, R31E, sec 14	Close-up photo of Los Medaños Mbr core, 983.9 - 985.2 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-8_Core100.jpg	6-26-05	SNL-8 drillpad; T22S, R31E, sec 14	Close-up photo of Los Medaños Mbr core, 984.9 - 986.2 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-8_Core101.jpg	6-26-05	SNL-8 drillpad; T22S, R31E, sec 14	Close-up photo of Los Medaños Mbr core, 985.9 - 987.2 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-8_Core102.jpg	6-26-05	SNL-8 drillpad; T22S, R31E, sec 14	Close-up photo of Los Medaños Mbr core, 986.9 - 988.2 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-8_Core103.jpg	6-26-05	SNL-8 drillpad; T22S, R31E, sec 14	Close-up photo of Los Medaños Mbr core, 987.8 - 989.2 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-8_Core104.jpg	6-26-05	SNL-8 drillpad; T22S, R31E, sec 14	Close-up photo of Los Medaños Mbr core, 988.9 - 990.3 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-8_Core105.jpg	6-26-05	SNL-8 drillpad; T22S, R31E, sec 14	Close-up photo of Los Medaños Mbr core, 989.9 - 991.3 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-8_Core106.jpg	6-26-05	SNL-8 drillpad; T22S, R31E, sec 14	Close-up photo of Los Medaños Mbr core, 990.8 - 992.2 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-8_Core107.jpg	6-26-05	SNL-8 drillpad; T22S, R31E, sec 14	Close-up photo of Los Medaños Mbr core, 991.8 - 993.2 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-8_Core108.jpg	6-26-05	SNL-8 drillpad; T22S, R31E, sec 14	Close-up photo of Los Medaños Mbr core, 992.9 - 994.3 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-8_Core109.jpg	6-27-05	SNL-8 drillpad; T22S, R31E, sec 14	Close-up photo of Los Medaños Mbr core, 994.3 - 995.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-8_Core110.jpg	6-27-05	SNL-8 drillpad; T22S, R31E, sec 14	Close-up photo of Los Medaños Mbr core, 994.9 - 996.1 ft bgl, with scale	DW Powers Consultant to WTS
SNL-8_Core111.jpg	6-27-05	SNL-8 drillpad; T22S, R31E, sec 14	Close-up photo of Los Medaños Mbr core, 995.9 - 997.2 ft bgl, with scale	DW Powers Consultant to WTS
SNL-8_Core112.jpg	6-27-05	SNL-8 drillpad; T22S, R31E, sec 14	Close-up photo of Los Medaños Mbr core, 996.9 - 998.1 ft bgl, with markings, scale	DW Powers Consultant to WTS

Camera: Nikon CoolPix 5700 **Resolution**: 2560 x 1920 **Page** X of Y

File	DATE	LOCATION	DESCRIPTION OF SUBJECT (includes individual/group names, direction, etc. as appropriate)	PHOTOGRAPHER (initials and dept.)
SNL-8_Core113.jpg	6-27-05	SNL-8 drillpad; T22S, R31E, sec 14	Close-up photo of Los Medaños Mbr core, 997.9 - 999.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-8_Core114.jpg	6-27-05	SNL-8 drillpad; T22S, R31E, sec 14	Close-up photo of Los Medaños Mbr core, 998.9 - 1000.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-8_Core115.jpg	6-27-05	SNL-8 drillpad; T22S, R31E, sec 14	Close-up photo of Los Medaños Mbr core, 999.9 - 1001.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-8_Core116.jpg	6-27-05	SNL-8 drillpad; T22S, R31E, sec 14	Close-up photo of Los Medaños Mbr core, 1000.9 - 1002.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-8_Core117.jpg	6-27-05	SNL-8 drillpad; T22S, R31E, sec 14	Close-up photo of Los Medaños Mbr core, 1001.9 - 1003.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-8_Core118.jpg	6-27-05	SNL-8 drillpad; T22S, R31E, sec 14	Close-up photo of Los Medaños Mbr core, 1002.9 - 1004.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-8_Core119.jpg	6-27-05	SNL-8 drillpad; T22S, R31E, sec 14	Close-up photo of Los Medaños Mbr core, 1003.9 - 1005.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-8_Core120.jpg	6-27-05	SNL-8 drillpad; T22S, R31E, sec 14	Close-up photo of Los Medaños Mbr core, 1004.9 - 1006.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-8_Core121.jpg	6-27-05	SNL-8 drillpad; T22S, R31E, sec 14	Close-up photo of Los Medaños Mbr core, 1005.9 - 1007.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-8_Core122.jpg	6-27-05	SNL-8 drillpad; T22S, R31E, sec 14	Close-up photo of Los Medaños Mbr core, 1006.9 - 1008.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-8_Core123.jpg	6-27-05	SNL-8 drillpad; T22S, R31E, sec 14	Close-up photo of Los Medaños Mbr core, 1007.9 - 1009.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-8_Core124.jpg	6-27-05	SNL-8 drillpad; T22S, R31E, sec 14	Close-up photo of Los Medaños Mbr core, 1008.9 - 1010.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-8_Core125.jpg	6-27-05	SNL-8 drillpad; T22S, R31E, sec 14	Close-up photo of Los Medaños Mbr core, 1009.9 - 1011.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-8_Core126jpg	6-27-05	SNL-8 drillpad; T22S, R31E, sec 14	Close-up photo of Los Medaños Mbr core, 1010.9 - 1012.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-8_Core127.jpg	6-27-05	SNL-8 drillpad; T22S, R31E, sec 14	Close-up photo of Los Medaños Mbr core, 1011.9 - 1013.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-8_Core128.jpg	6-27-05	SNL-8 drillpad; T22S, R31E, sec 14	Close-up photo of Los Medaños Mbr core, 1012.8 - 1013.2 ft bgl, with markings, scale	DW Powers Consultant to WTS

Camera: Nikon CoolPix 5700 **Resolution**: 2560 x 1920 **Page** X of Y

Unidentified flowering plant in sand near SNL-8. Photo by Dennis W. Powers, June 15, 2005.

Appendix G
Geophysical Logs

Geophysical logging of SNL-8 was conducted by Jet West Geophysical Services, LLC, 2550 La Plata Highway, Farmington, NM, 87499-3522, on June 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
- Neutron
- Resistivity and spontaneous potential (below 806 ft)

SNL-8 had been cored to 1,012 ft, plugged back to 991 ft with HolePlug, and reamed to 11-inch diameter to 995 ft at the time of logging. Fill in the hole prevented logging below 981 ft. A conductor casing had been placed to a depth of 37 ft bgl. The fluid level had risen in the drillhole, from inflow, to approximately 806 ft below the surface at the time of logging. SNL-8 was drilled with air and foam, with little water introduced during drilling and considerable water produced uphole.

The caliper log was used 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 3353 ft amsl based on the pre-drilling pad elevation of 3,352.75 ft. A benchmark placed near the drillhole after completion has an elevation of 3,353.18 ft amsl (see Fig. 1-5 and Table 1-1 in the main text). The rounded elevation of 3,353 ft amsl for the reference point is appropriate for the measurements and elevations of units for later studies.

Geophysical logging at SNL-8 on June 28, 2005, by Jet West, with logging truck in position (above). Geophysical tool inside casing (right) being set with respect to the top of the surface casing before logging.

Figure 2-1
Well Record SNL-8 (C-3150)

Company: Washington TRU Solutions LLC
Well: SNL-8 (C-3150)
Section: 14 Twp: T22S Rge: R31E
Location: 853 ft from south line (fsl)
116 ft from east line (fel)

T22S
R31E
14

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

Elevation
KB:
DF:
GL: 3553 ft amsl
(benchmark: 3553.18)

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: June 13, 2005
Completion date: June 28, 2005
Total depth (TD): 1012 ft bgl (driller log)

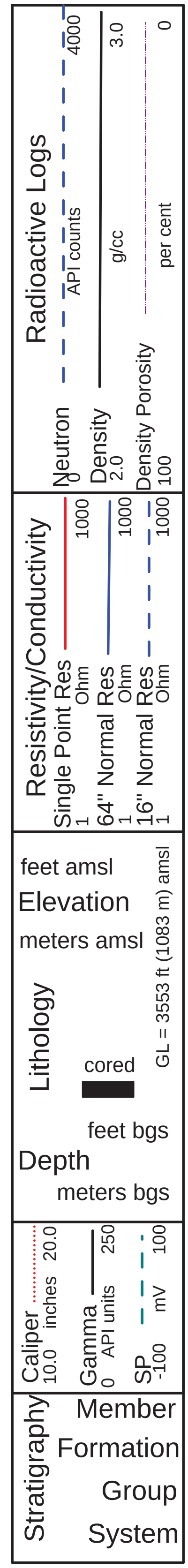
Casing Record
Conductor: 37 ft
12.75 inch o.d. steel
Casing: 5.45 inch o.d.
fiberglass reinforced
plastic to 981 ft bgl
Screened interval:
978-952 ft bgl

Geophysical Logs Date: June 28, 2005

Micro/Laterolog/SP:	0-981 ft
Gamma/Fluid:	0-978 ft
Caliper:	0-975 ft
Density/Neutron:	0-991 ft

Type fluid in hole: water
from drillhole to 803 ft
Res mud: n/a
Res mud filtrate: n/a
Max. Rec. Temp.:
not recorded

SNL-8 Well Log Headers



General Lithologic Symbols Used

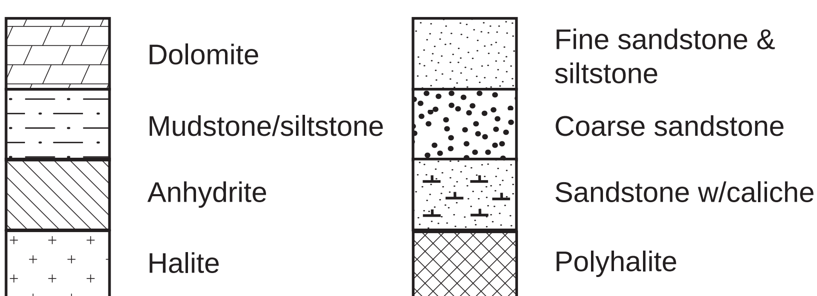
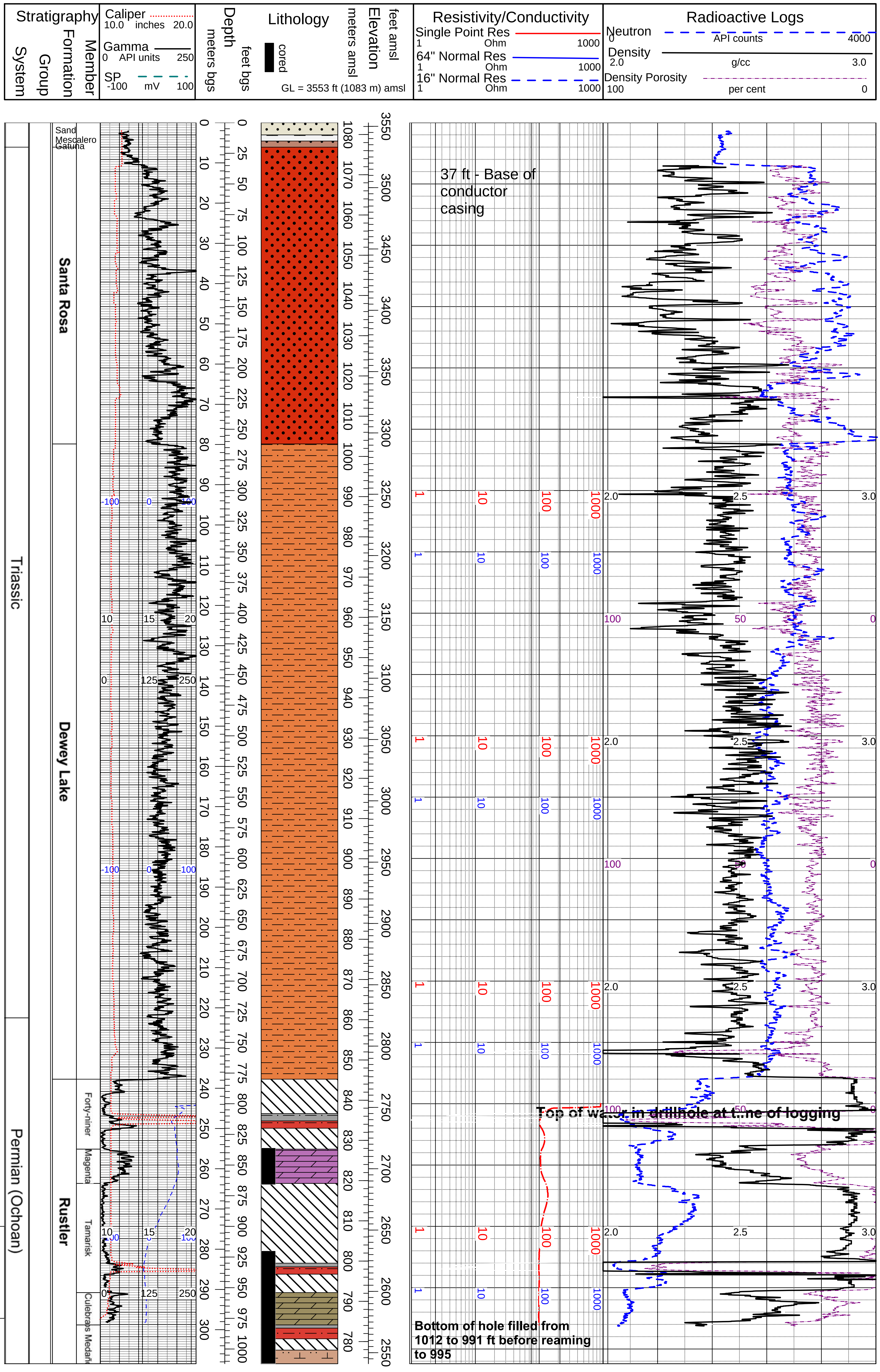


Figure 2-1 Log Title & Header page.ai



Stratigraphy
System
Group
Formation
Member
Caliper
10.0 inches 20.0
Gamma
0 API units 250
SP
-100 mV 100
Depth
meters bgs
feet bgs
Lithology
cored
GL = 3553 ft (1083 m) amsl
Elevation
meters amsl
feet amsl
Resistivity/Conductivity
Single Point Res
1 Ohm 1000
64" Normal Res
1 Ohm 1000
16" Normal Res
1 Ohm 1000
Radioactive Logs
Neutron
0 API counts 4000
Density
2.0 g/cc 3.0
Density Porosity
100 per cent 0
Triassic
Permian (Ochoan)
Santa Rosa
Dewey Lake
Rustler
Sand
Mescalero
Gatuna
Forty-niner
Magenta
Tamarisk
Culebra
37 ft - Base of conductor casing
Top of water in drillhole at time of logging
Bottom of hole filled from 1012 to 991 ft before reaming to 995

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