DOE/WIPP 04-3305

Basic Data Report
For Drillhole SNL-5 (C-3002)
(Waste Isolation Pilot Plant)

April to October 2004

Processing and final preparation of this report was performed by the Waste Isolation Pilot Plant Management and Operating Contractor for the U.S. Department of Energy under Contract No. DE-AC29-01AL66444.

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For Drillhole SNL-5 (C-3002)
(Waste Isolation Pilot Plant)

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April to October 2004

West Texas Water Well Service Rig #15 at SNL-5, viewed toward the northeast. The rig is being set up for drilling with compressed air. A surface diverter is being placed before drilling to set the steel surface conductor casing. Taken April 27, 2004, by Dennis W. Powers.

EXECUTIVE SUMMARY

SNL-5 (permitted by the New Mexico State Engineer as C-3002) was drilled and completed in April to May 2004 to provide geological data and hydrological testing of the Culebra Dolomite Member of the Permian Rustler Formation in an area north of the Waste Isolation Pilot Plant (WIPP) site where data are sparse and where a pumping or monitoring well for a northern pumping test is needed. SNL-5 is located in the southeast quarter of section 6, T22S, R31E, in eastern Eddy County, New Mexico. SNL-5 was drilled to a total depth of 687 ft below ground level (bgl), based on driller's measurements. Below the caliche pad, SNL-5 encountered the Mescalero caliche, Gatuña, Dewey Lake, and Rustler Formations. Two intervals of the Rustler were cored: (1) from the lower Forty-niner Member through the Magenta Dolomite Member and into the upper Tamarisk Member; and (2) from the lower Tamarisk Member through the Culebra Dolomite and into the upper Los Medaños Members. Geophysical logs were acquired from the open hole to a depth of ~672 ft. No water was observed to flow into the open drillhole until the Culebra was penetrated.

The upper part of the Los Medaños has normal lithology, thickness, and stratigraphic sequence. The upper M-1/H-1 included halite and halite-cemented siltstone, consistent with margins of halite previously estimated. The upper clastic unit of the Los Medaños (M-2/H-2) at SNL-5 was well preserved in cores, and it did not include halite, consistent with estimates. The contact with the overlying Culebra was not recovered as a single core, but the surface of the uppermost core from M-2 does not indicate significant deformation.

Core recovery from the Culebra was excellent, revealing a unit that is generally less porous than cores from most other locations recently drilled. Some porosity appears, from the core surface, to be filled partially with silt. Fractures are neither extensive nor common, and the unit is not expected to have high transmissivity based on core observations. The Culebra is 23 ft thick, which is normal for the unit.

The Tamarisk has a normal stratigraphic sequence and thickness. The basal sulfate unit includes horizontal beds and laminae near the base, and the uppermost part shows some inclined bedding. The mudstone unit shows mostly reddish-brown claystone and siltstone with some gray mottling. Clasts or intraclasts are also included in the unit. The upper Tamarisk sulfate is somewhat brecciated near the base.

The Magenta Dolomite is about 24 ft thick and shows typical laminar to wavy bedding, some ripples, and algal stromatolites. Carbonate interbeds in sulfate at both contacts are sparse, indicating depositional environments changed with few fluctuations. The core was well preserved and the unit was completely recovered. Porosity is limited, and the cores indicate a thin zone of slightly greater porosity in the upper part of the Magenta. A thin nodular sulfate bed in the upper part of the Magenta corresponds stratigraphically to a thicker, similar unit recovered from SNL-1, to the north.

The Forty-niner is represented by a typical sulfate–mudstone–sulfate sequence. The basal sulfate was partially cored, displaying thin carbonate laminae and beds in gypsum. Cuttings did not indicate any halite present in the mudstone unit, consistent with previous studies. The mudstone cuttings indicate a lower light brownish gray siltstone, estimated to be 7 ft thick, and an upper reddish brown argillaceous siltstone and sandstone. Sulfate cuttings were limited.

The Dewey Lake is thicker at SNL-5 than in some of the nearby holes recently drilled. It has not been as extensively eroded at the top prior to deposition of the Gatuña. Sulfate was observed in the Dewey Lake at 207 ft, which is higher stratigraphically than in some other wells recently drilled. Geophysical logs show higher resistivity from 210–260 ft that would be consistent with sulfate cements; more detailed examination of cuttings may resolve this difference. The Santa Rosa appears to have been eroded from the SNL-5 location before the Gatuña was deposited.

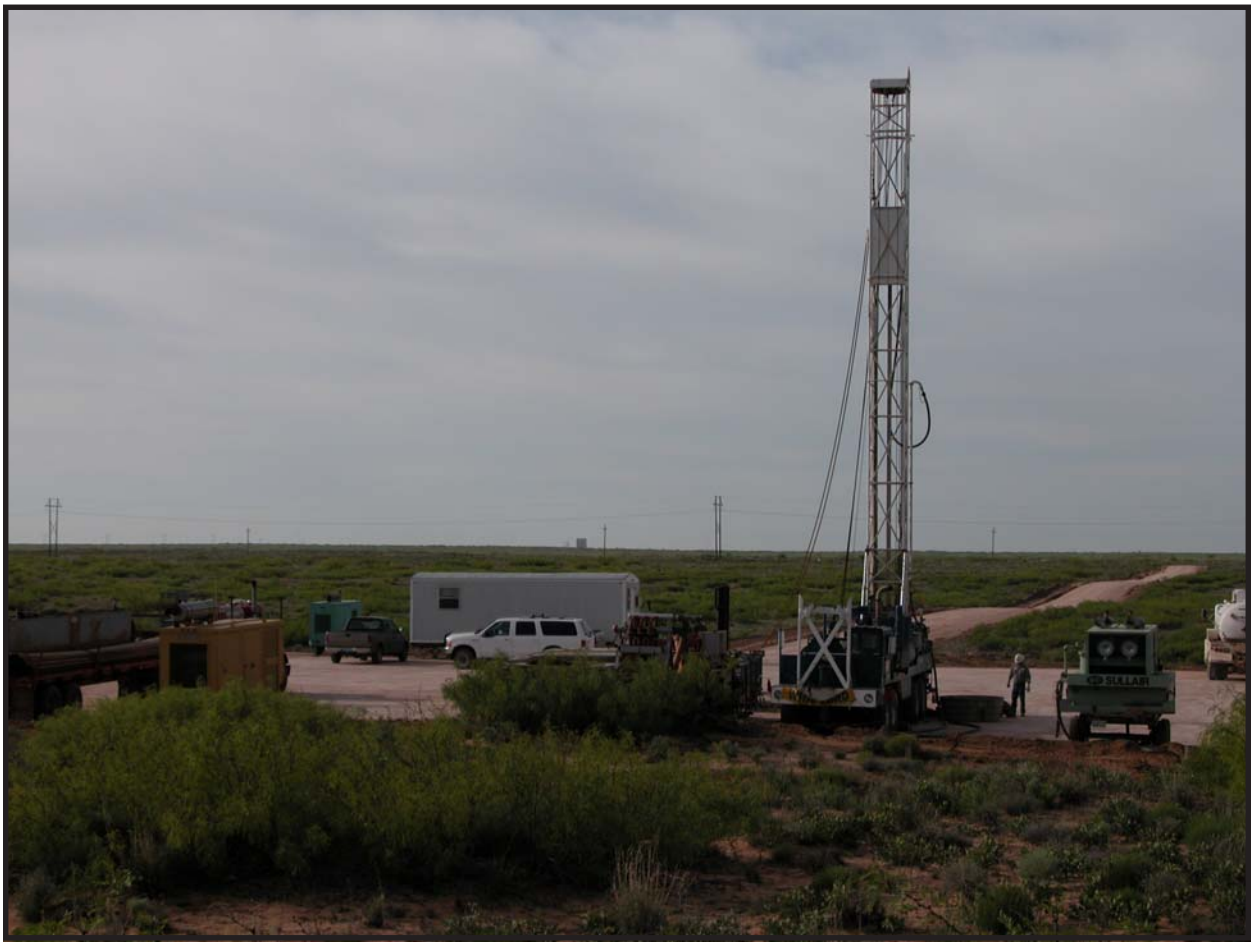
The Gatuña at SNL-5 is mainly sandstone, with carbonate infiltrated at the top. Chert pebbles and

Manganese oxide stains found here in the Gatuña are also common elsewhere.

The Mescalero caliche is ~3 ft thick at SNL-5, but cuttings were insufficient to determine the stage of development of the Mescalero.

SNL-5 was drilled (and reamed through cored intervals) with an original diameter of 11 inches to the depth for completion, and this diameter was sufficient to complete the hole without additional reaming. Fiberglass reinforced plastic (FRP) casing (4.83 inches outside diameter) was placed in the hole, with a screen interval across the Culebra Dolomite from 660–633.7 ft below the top of the connector on the conductor casing. Approximately 2 ft of FRP casing was left above the connector. The annulus was filled with 8/16 Brady sand to 625 ft, above the Culebra, and bentonite (Hole Seal) was placed to 620 ft to separate the Culebra from the Tamarisk mudstone. The annulus above the bentonite was cemented to the surface.

SNL-5 was cleaned May 11, 2004, by jetting at 200–250 psi with about 180 barrels of fresh water. On May 19, 2004, the well was pumped at variable rates from 5–12 gallons per minute (gpm) and backwashed over a period of 7 hours. On May 20, 2004, SNL-5 was pumped for 5.75 hours at a beginning rate of 12 gpm, decreasing to 5 gpm. The final fluid density was 1.006 grams per cubic centimeter at 25.2°C. On June 7, 2004, the measured water level was 3068.28 ft above mean sea level (ft amsl), and the fresh-water-equivalent level was 3070.30 ft amsl.



West Texas Water Well Service rig #15 at SNL-5 as surface diverter was being put in place to drill the hole for the surface conductor casing. The Waste Handling Building is on the horizon near the center. Taken by Dennis W. Powers April 27, 2004.

Table of Contents

List of Figures and Tables

In keeping with practice at the WIPP site, the basic data for SNL-5 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)

Wildflowers in sand dunes near SNL-5. May 2004. Photos by Dennis W. Powers

1.0 INTRODUCTION

SNL-5 was drilled in the southeast quarter of Section 6, T22S, R31E, in eastern Eddy County, New Mexico (Fig. 1-1). It is located 2011 ft from the south line (fsl) and 369 ft from the west line (fwl) of the section (Fig. 1-2). This location places the drillhole north of the WIPP site and between recent drillholes SNL-2 and SNL-3. SNL-5 was begun late in April 2004 and was completed early in May. SNL-5 will be used to test hydraulic properties and to monitor groundwater levels of the Culebra Dolomite Member of the Permian Rustler Formation for the WIPP.

SNL-5 was permitted by the New Mexico State Engineer as C-3002. 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 below ground level (bgl).

1.2 Purpose of SNL-5

SNL-5 was designed and located to provide information for the integrated hydrology program for the WIPP (Sandia National Laboratories, 2003). Among the objectives of the integrated hydrology program, SNL-5 will help "… resolve questions related to observed water-level changes around the 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 (Sandia National Laboratories, 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 based on these factors.

SNL-5 was located to test Culebra hydraulic properties in an area north of WIPP where data are sparse. Previous studies indicated that halite would be present in the lower Rustler at SNL-5, and the location appeared to be along the end of a modest plunging syncline expressed by the Culebra (Sandia National Laboratories, 2003; Powers, 2002a, 2003a; Powers and others, 2003).

The drillhole is to (Sandia National Laboratories, 2003, p. 44; see also Appendix A):

1. Provide transmissivity data in a key area north of the WIPP site;
2. Determine vertical head gradients north of the WIPP site; and
3. Provide a location for a large-scale (multipad) pumping test to provide transient data for calibration of the Culebra model north of the WIPP site.

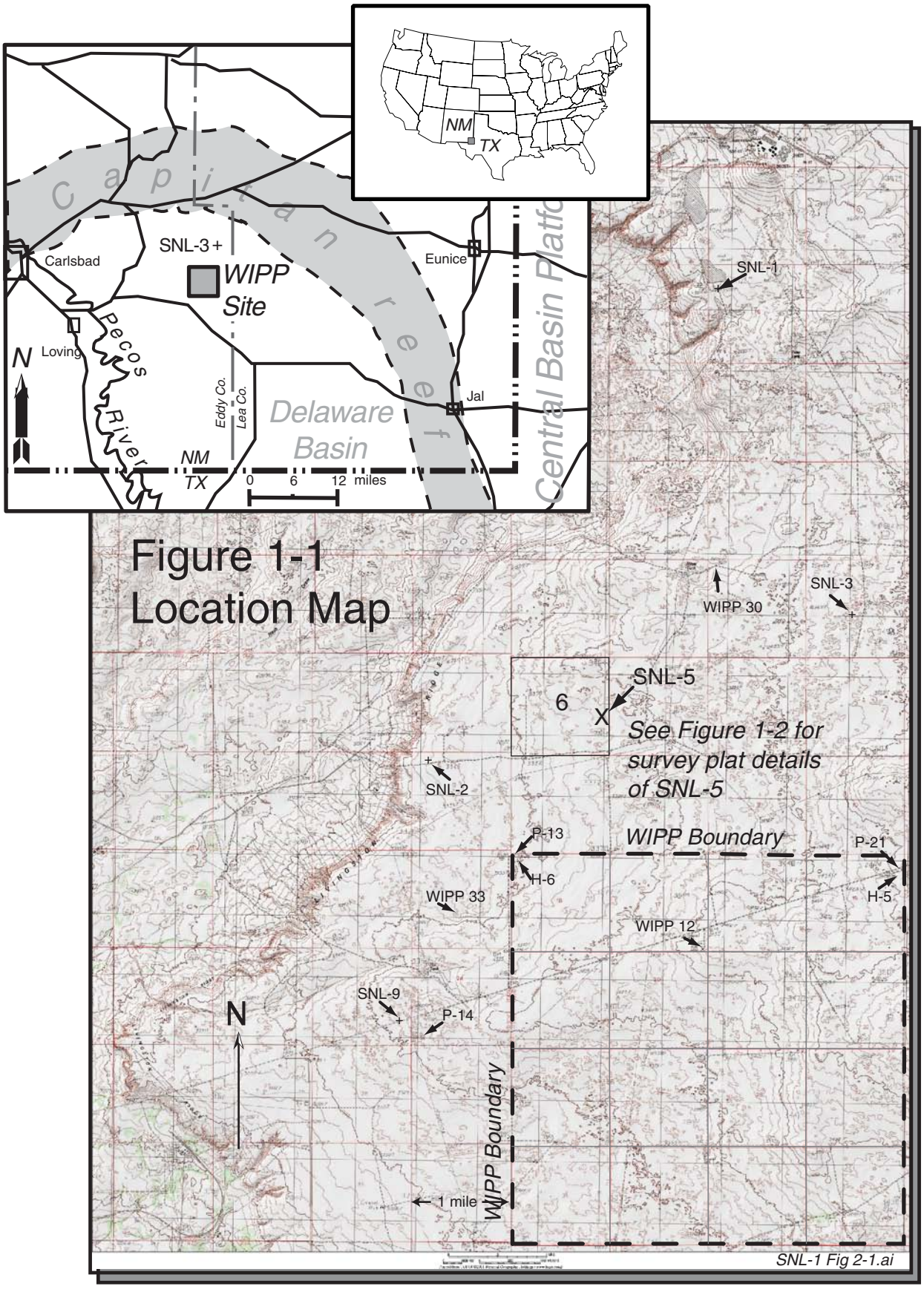


Figure 1-1
Location Map

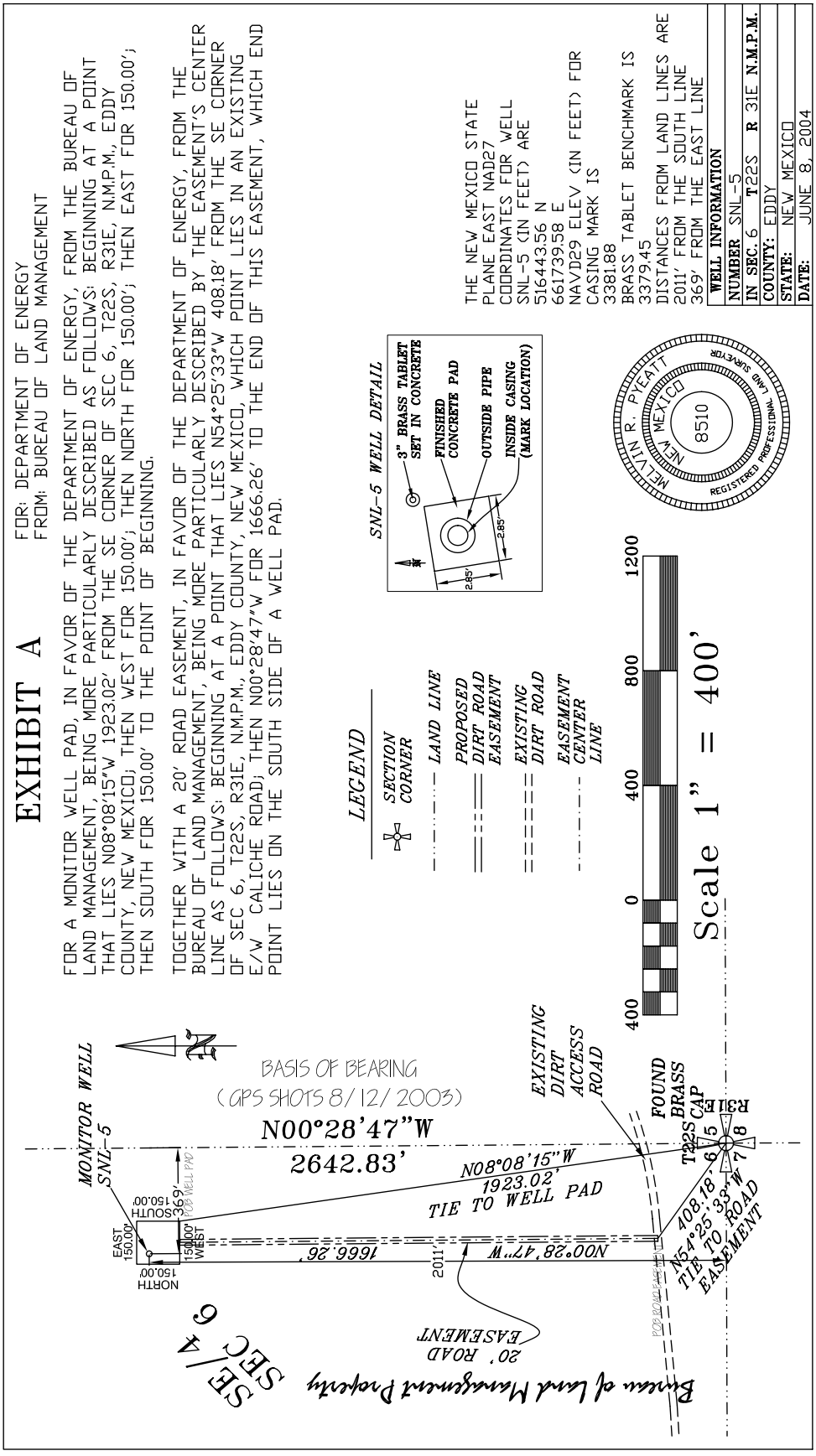


Figure 1-2
Survey Plat
for SNL-5

1.3 SNL-5 Drilling and Completion

The basic information about drilling and completion of SNL-5 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-5 was rotary drilled and cored to a total depth of 687 ft bgl (Fig. 1-3) as measured during drilling and coring. Geophysical logging indicated approximately 2 ft greater depth to stratigraphic contacts in the lower part of SNL-5, and the total depth is estimated to be about 689 ft based on this difference. Figures based on geophysical logs show these greater depths. SNL-5 was drilled using compressed air (two compressors) with a small added volume of water and Quik–Foam® to improve cuttings returns. Cuttings from SNL-5 were much larger and more useful, compared to previous drillholes, because of these methods.

Core recovery was excellent throughout, with recovered lengths equalling or, for one run, slightly exceeding the cored interval as measured during drilling (Table 1-1; Appendix C). The core recovery through the Culebra far exceeded what is common (e.g., Powers, 2002b; Mercer and others, 1998).

In keeping with recent practice at WIPP, SNL-5 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 similar to SNL-5 (Sandia National Laboratories, 2003).

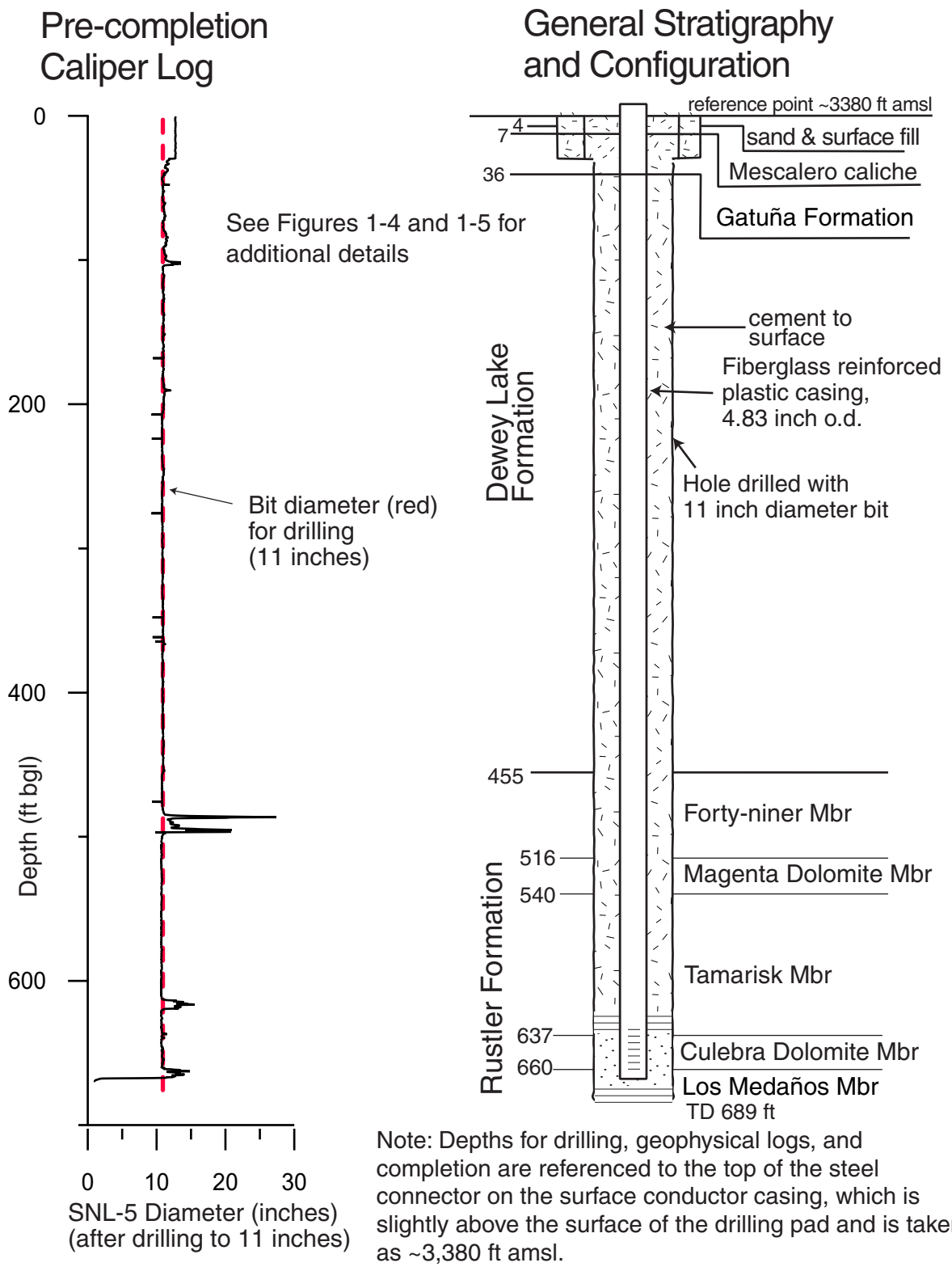
SNL-5 was completed with a single screened interval for monitoring and testing of only the Culebra Dolomite (Fig. 1-4). With a single completion interval, some of the difficulties associated with multiple completions can be avoided: expense of buying, placing, and maintaining packers; loss of water level 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-5 wellpad (Sandia National Laboratories, 2003).

Geophysical logs, especially the natural gamma and caliper logs, were used to make the final decisions regarding completion of SNL-5 (Fig. 1-4) (Appendices D and E). The drillhole penetrated the uppermost part of the lower Rustler, and HolePlug® was put into SNL-5 to prevent circulation into that interval (Fig. 1-4). The bottom of the Culebra screen interval was placed at 660 ft to remain above the claystone below the Culebra and avoid possible plugging of the lowermost slots (Fig. 1-4). The top of the screen, at 633.7 ft, is above the top of the Culebra. The top of the sand pack (8/16 silica sand) (note: the material is referred to as a sand pack for simplicity, although the larger grain diameter slightly exceeds the standard upper limit for sand size) at 625 ft is below the level of the mudstone in the Tamarisk to prevent connection to the Culebra. Bentonite (HolePlug®) was placed to 620 ft, and the annulus above the bentonite was cemented to the surface. The caliper log (Fig. 1-3) after the drillhole was drilled to 687 ft at a diameter of 11 inches and before the casing was placed shows zones of drillhole enlargement in the Forty-niner and Tamarisk mudstones as well as in the mudstone just below the Culebra. The annulus behind the casing was cemented through the upper two enlarged intervals.

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.

Reference points for measurements at SNL-5 varied slightly during the course of drilling and completing the well and later monitoring of water levels. The surficial deposits were drilled to a depth of 30 ft with a temporary diverter in place to direct air flow and cuttings. A steel surface conductor casing was then cemented in place to a depth of 29.6 ft below the surface, and the top of the steel connector on the conductor casing (Fig. 1-6) was used as a

Figure 1-3
SNL-5 As-Built Diagram



Note: Depths for drilling, geophysical logs, and completion are referenced to the top of the steel connector on the surface conductor casing, which is slightly above the surface of the drilling pad and is taken as ~3,380 ft amsl.

Table 1-1. Summary of Drilling and Well Completion Records for Hydrologic Drillhole SNL-5 (C-3002)

LOCATION: Southeast ¼, Section 6, Township 22 South (T22S), Range 31 East (R31E)

SURFACE COORDINATES: The well is located 2,011 ft from the south line (fsl) and 369 ft from the east line (fel) of Section 6. The New Mexico State Plane (NAD 27) horizontal coordinates in feet are 516443.56 North, 661739.58 East (Fig. 1-2 shows the survey plat). Universal Transverse Mercator (UTM) horizontal coordinates (NAD27, Zone 13) in meters were calculated for SNL-5 using Corpscon for Windows (v. 5.11.08): 611969.97 East, 3587284.66 North. Figure 1-1 shows UTM coordinates on a 1000-m grid.

ELEVATION: All depths used in geological and geophysical data were measured from the top of the connector on the steel surface conductor casing just above the level of the drillpad surface (Figs. 1-5, 1-6). Depths are reported as below ground level (bgl), which is taken as 3,380 ft above mean sea level (amsl), the rounded up value for the brass tablet benchmark (3,379.45 ft amsl) adjacent to the cement well pad. The primary datum for the completed well is 3,381.88 ft amsl (NAVD 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-5.

DRILLING RECORD:

Dates: Began drilling April 27, 2004; drillhole reached total depth (687 ft) on May 5, 2004. Geophysical logging was conducted on May 7, 2004. Drillhole was prepared for casing, and was cased and cemented May 10, 2004. Rig was moved off the drillpad May 12, 2004. SNL-5 well development began with jetting the screened interval on May 11, 2004; the well was pumped May 19 and 20, 2004, for initial development.

Circulation Fluid: SNL-5 was drilled to 30 ft bgl with circulating air and a small amount of fresh water and Quik–Foam®, discharging cuttings into a lined portable steel container. After the surface conductor casing was cemented, SNL-5 was drilled and cored to total depth of 687 ft bgl (driller's depth) using the same method. The hole was drilled (and reamed following coring) using an 11-inch bit and did not require additional reaming to complete.

Cored Intervals: 4.0-inch core was taken through these intervals (depths from drilling data):
512.0–542.0 ft bgl: lower Forty-niner, Magenta Dolomite, and upper Tamarisk Members
598.0–687.3 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-5 (C-3002), continued.

Drillhole Record:

Size (inches)	From (ft bgl)	To (ft bgl)
18	0	30
11	30	687.3

Casing Record:

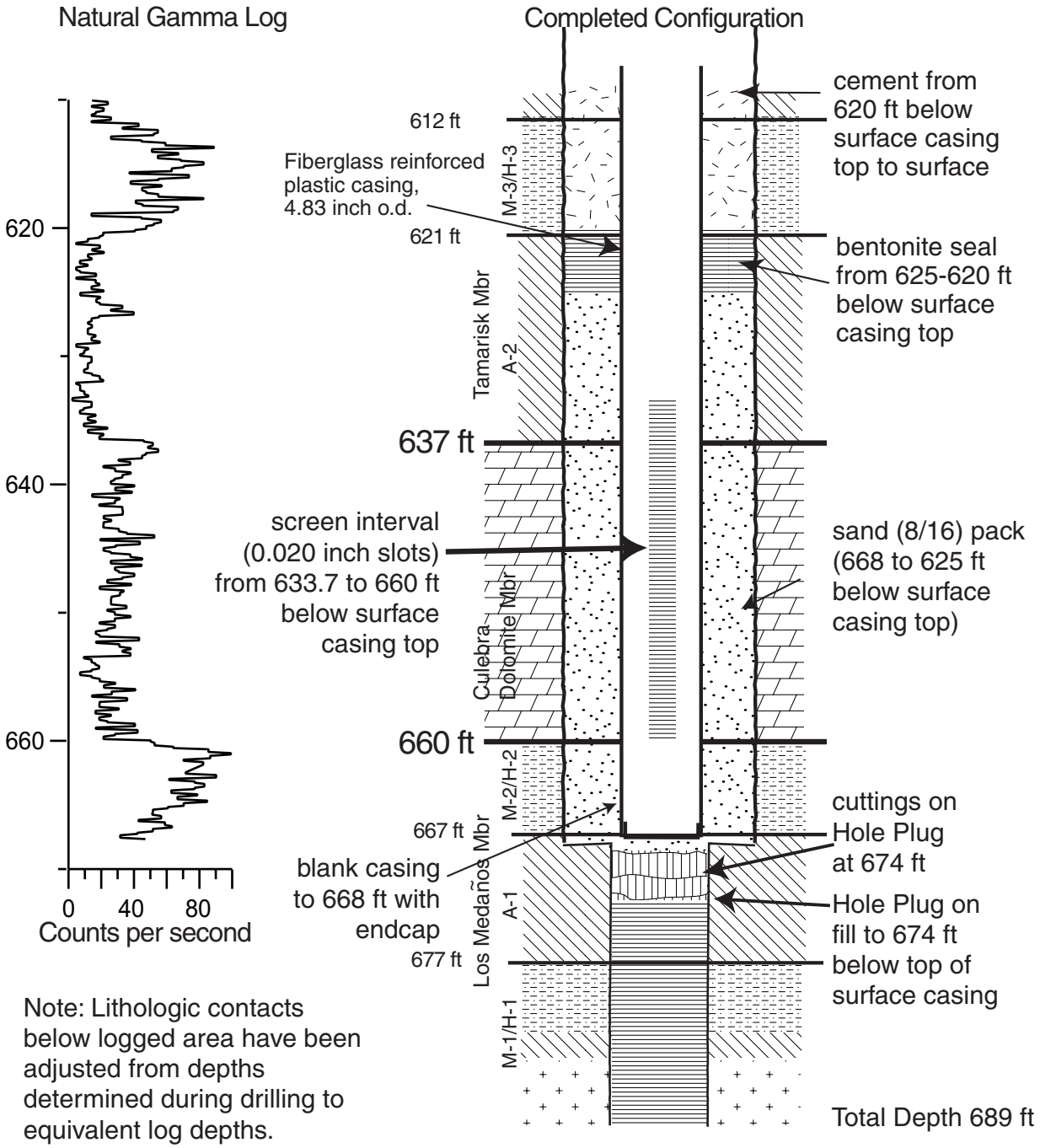
Outside diameter (inches)	Inside diameter (inches)	Weight/ft (pounds)	From (ft bgl)*	To (ft bgl)
13.38	12.72	48 steel	0	29.6
4.83	4.33	3.20 FRP** blank	-2.0	633.70
4.83	4.33	3.20 FRP screen	633.70	660.0
4.83	4.33	3.20 FRP blank	660.0	668.0

*Top of the casing connector is the reference for depth denoted below ground level (bgl). The FRP extends 2 ft (-2) above the steel casing connector.
**FRP: fiberglass reinforced plastic

Coring Record:

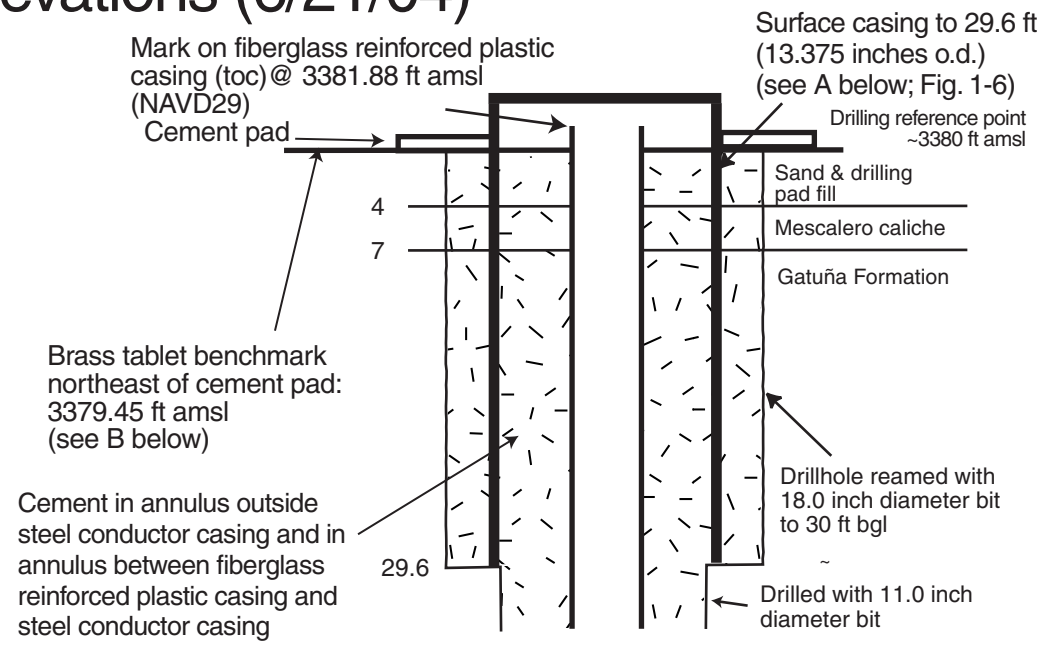
Core Run No.	Depth Interval (ft) From	To	Interval (ft) Cored	Recovered	Recovered %
1	512	542	30	30	100.00%
2	598	627.3	29.3	29.3	100.00%
3	627.3	657.3	30	30	100.00%
4	657.3	687.3	30	30	100.00%
		Totals	119.3	119.3	100.00%

Figure 1-4
SNL-5 Completion and Monitoring Configuration (5/8/04)



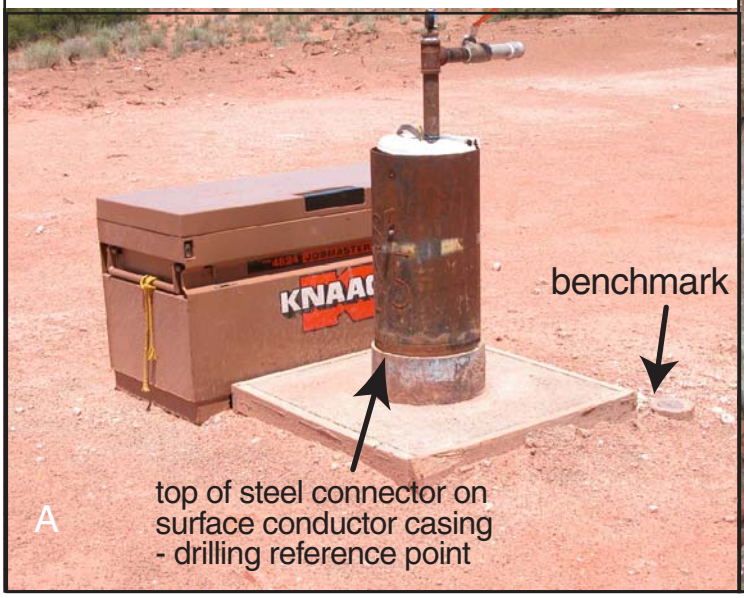
Note: Lithologic contacts below logged area have been adjusted from depths determined during drilling to equivalent log depths.

Figure 1-5
SNL-5 Surface Configuration and Elevations (6/21/04)



B - Detail of brass tablet benchmark on northeast corner of SNL-5 cement pad. Elevation 3379.45 ft amsl.

A - Surface casing for SNL-5 with cap and padlock off and well set up for continuous water level monitoring.



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 3,380 ft amsl, based on the topographic map elevation, and geophysical logs reflect this information. The benchmark placed at the drilling pad surface next to the completed well has an elevation of 3,379.45 ft amsl. *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 ~3,380 ft amsl (Figs. 1-3, 1-4, and 1-5).* Geological and geophysical data collected during this investigation for completing the well are better represented by this proxy reference point and elevation than by attempting to correct to a surveyed point on the drill pad. The FRP casing projects ~2 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 (3,381.88 ft amsl) for monitoring water levels.

Figure 1-6 Reference Point for Drilling and Logging at SNL-5

1.4 Other Background

SNL-5 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 Raymond Federwisch, Geophysical Logging Services, 6250 Michele Lane, Prescott, Arizona, under contract to West Texas Water Well Service. Geological support was provided by Dennis W. Powers under contract to WTS. Tim Williams of the New Mexico Office of the State Engineer witnessed hole completion activities (Appendix E). Well drilling wastes (cuttings and mud) were removed from SNL-5 and disposed of at the Lea Land, Inc. landfill north of WIPP. Pumped fluids were disposed of at the H-19 disposal site operated by 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 F). Cores from SNL-5 were photographed with a digital camera, and a photo log is included in Appendix G. Electronic images can be requested from WTS.

1.5 Acknowledgements

Drafts of this document were reviewed by Mark Crawley, Wayne Stensrud, 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. Raymond Federwisch (Geophysical Logging 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-5.

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 to have mainly 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-5

SNL-5 encountered a normal stratigraphic sequence from ground level to total depth for this location north of the WIPP site area, (Fig. 2-1; Table 2-1). Units encountered ranged from unconsolidated surficial alluvium 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. Units above the Culebra did not yield noticeable water during drilling.

The geologic units encountered in SNL-5 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. The largest differences between depths determined by geophysical logging and core markings based on depths measured during drilling is approximately 3 ft through lower units in SNL-5. Decisions about placing screen intervals and annulus fillings were based on depths indicated by geophysical logs (Appendix D).

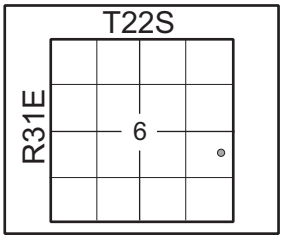
Note that the descriptions that follow use depths that correspond to core markings, with basic stratigraphic intervals provided by geophysical logs, as indicated.

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 455 ft (Fig. 2-1), and 234 ft of the Rustler were penetrated at SNL-5 (Table 2-1).

Figure 2-1
Well Record SNL-5 (C-3002)

Company: Washington TRU Solutions LLC
Well: SNL-5 (C-3002)
Section: 6 Twp: T22S Rge: R31E
Location: 2011 ft from south line (fsl)
369 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: 3380 ft amsl
(benchmark: 3379.45)

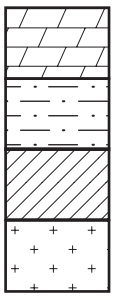
Drilling contractor: West Texas Well Water Service
Coring contractor: Diamond Oil Well Drilling Co.
Geophysical logs: Raymond Federwisch
Geophysical Logging Services (AZ)
Geologist: Dennis W. Powers
Spud date: April 27, 2004
Completion date: May 10, 2004
Total depth (TD): 687 ft bgl (driller log)

Casing Record
Conductor: 30 ft
13.375 inch steel
Casing: 4.83 inch o.d.
fiberglass reinforced
plastic to 629.5 ft bgl
Screened interval:
633.7-660.0 ft

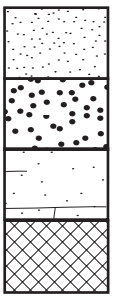
Geophysical Logs Date: May 7, 2004
Micro/Laterolog/Induction/SP: 0-671 ft
Gamma/Fluid: 0-671 ft
Caliper: 0-671 ft
Density/Neutron: 0-671 ft

Type fluid in hole:
Water below 324 ft
Res mud: n.d.
Res mud filtrate: n.d.
Max. Rec. Temp.:
28.2°C (in water)

General Lithologic Symbols Used



Dolomite
Mudstone/siltstone
Anhydrite
Halite



Fine sandstone & siltstone
Coarse sandstone
Sandstone w/caliche
Polyhalite

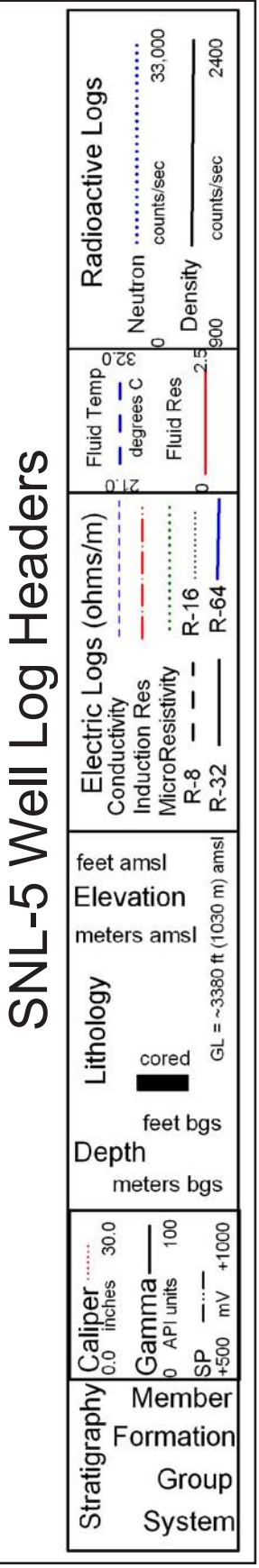


Figure 2-1 Log Title & Header page.ai

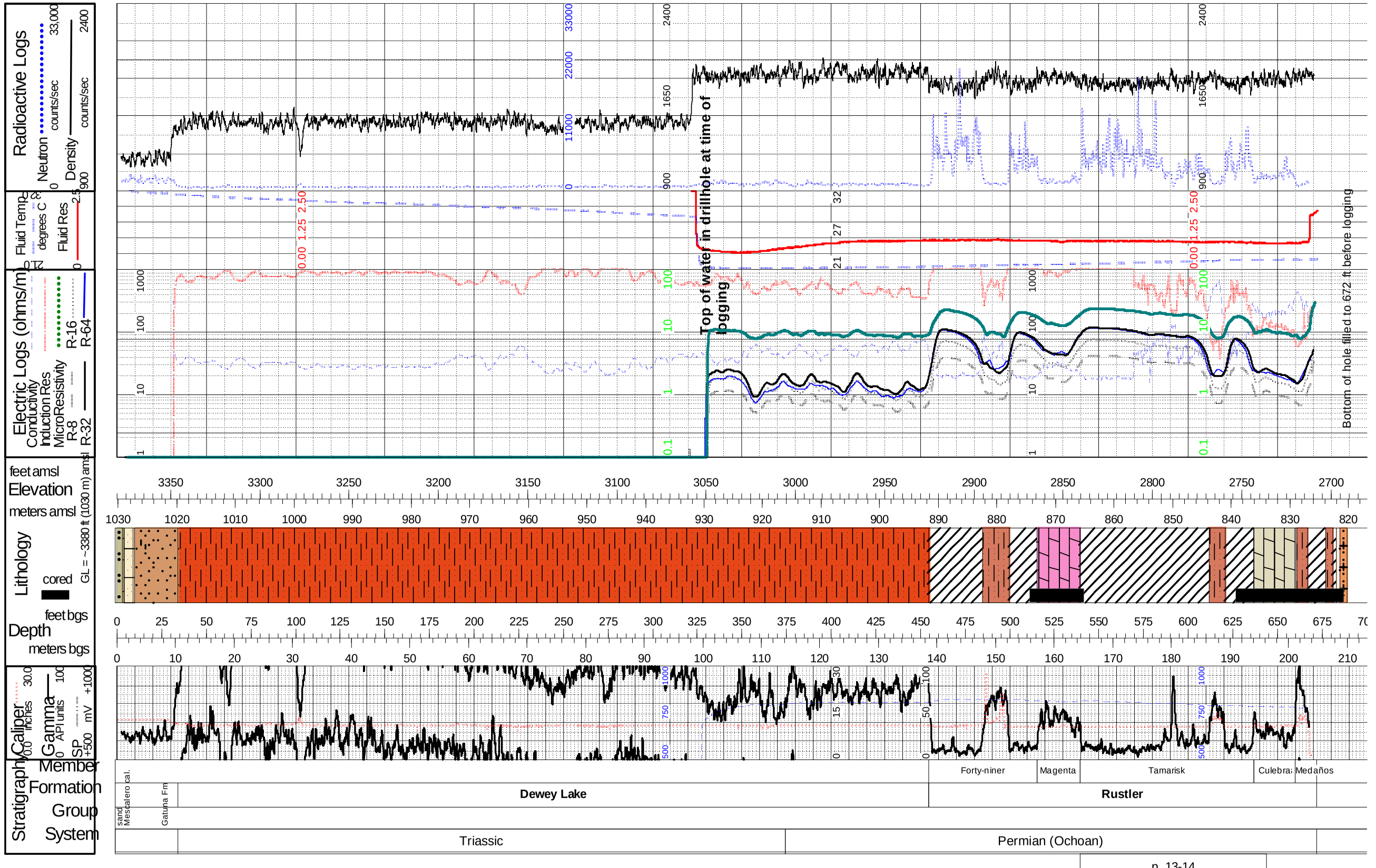

Electric Logs (ohms/m)
Conductivity
Induction Res
MicroResistivity
R-8
R-32
R-16
R-64
Fluid Temp
degrees C
Fluid Res
Radioactive Logs
Neutron
counts/sec
Density
counts/sec
Top of water in drillhole at time of logging
Bottom of hole filled to 672 ft before logging
feet amsl
Elevation
meters amsl
GL = ~3380 ft (1030 m) amsl
Lithology
cored
feet bgs
Depth
meters bgs
Caliper
inches
Gamma
API units
SP
mV
Stratigraph
Member
Formation
Group
System
Forty-niner
Magenta
Tamarisk
Culebra
Medaños
Dewey Lake
Rustler
sand
Mescalero cal.
Gatuna Fm
Triassic
Permian (Ochoan)

Table 2-1
Geology at Drillhole SNL-5

System/ Period/Epoch		**Formation or unit**	**Member** *Informal units*	**Depth below surface (ft)**[1]
Cenozoic	Holocene	surface dune sand and pad fill		0 - 4 ft
	Pleistocene	Mescalero caliche		4 - 7 ft
	Miocene-Pleistocene	Gatuña		7 ft - 36 ft
Mesozoic	**Triassic**	Santa Rosa[2]		eroded
		Dewey Lake[3]		36 ft - 455 ft
Paleozoic	**Permian**	Rustler	Forty-niner *A-5* *M-4/H-4* *A-4*	455 ft - 516 ft *455 ft - 484 ft* *484 ft - 499 ft* *499 ft - 516 ft*
			Magenta Dolomite	516 ft - 540 ft
			Tamarisk *A-3* *M-3/H-3* *A-2*	540 ft - 637 ft *540 ft - 612 ft* *612 ft - 621 ft* *621 ft - 637 ft*
			Culebra Dolomite	637 ft - 660 ft
			Los Medaños[4] *M-2/H-2* *A-1* *M-1/H-1*	660 ft - 689 ft *660 ft - 667 ft* *667 ft - 677 ft* *677 ft - 689 ft (TD)*[5]

[1]Depths are based on measurements by geophysical logging; drilling and coring provided supplemental data to total depth (TD) of 689 ft bgl. Geophysical logs and drilling/coring depths begin at the top of the connector on the surface steel conductor casing. This reference point is taken as 3,380 ft amsl; it is above the elevation of the surface benchmark adjacent to SNL-5. 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, mainly in the lower part of SNL-5.

[2]The Santa Rosa Formation, part of the Dockum Group or undifferentiated Triassic, is apparently completely eroded at SNL-5; the Santa Rosa is present nearby.

[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.

[5]The driller's total depth was 687 ft. Geophysical logs of the Culebra showed contacts 2.1 ft deeper than drilling logs. Drilling depths of units below the log interval were increased by ~2 ft in 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 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.

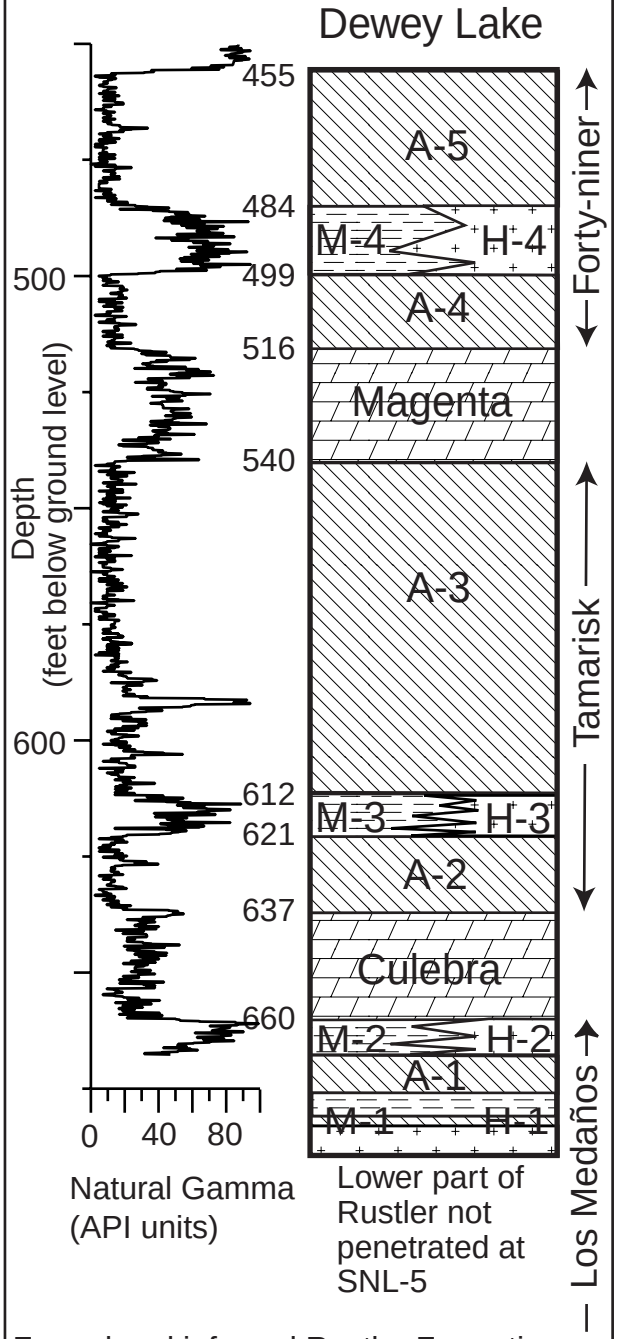
The upper part of the Los Medaños was cored (29 ft) in SNL-5, penetrating through A-1 and into the upper M-1/H-1 (Table 1-1).

The informal unit *mudstone-halite 1* (M-1/H-1; Fig. 2-2) was encountered from 674.8–687.3 ft (core markings). Fill in the drillhole prevented geophysical logging. The (rounded) depth based on extending the depth measured by geophysical logs is 677–689 ft (Table 2-1).

Halite is present from 679.9–687.3 ft, as marked on core. The lower 4.3 ft is a halite-cemented siltstone, and some of the halite crystals appear to have been corroded by dissolution. The upper 3.1 ft are mainly halite with two thin sulfate beds. The lower sulfate is a composite of several thin beds with halite and is overlain by coarse, nearly pure halite (Fig. 2-3). The uppermost halite (Fig. 2-4) is overlain by reddish-brown siltstone and bedded anhydrite and gypsum at 679.7 ft. The contact and bedding indicate the siltstone accumulated, probably on a surface exposed subaerially, before the sulfate was deposited.

The reddish-brown siltstone from 674.8–679 ft includes subrounded clasts of siltstone in the basal portion indicating erosion and transport (Fig. 2-5).

Figure 2-2
Rustler Units at SNL-5

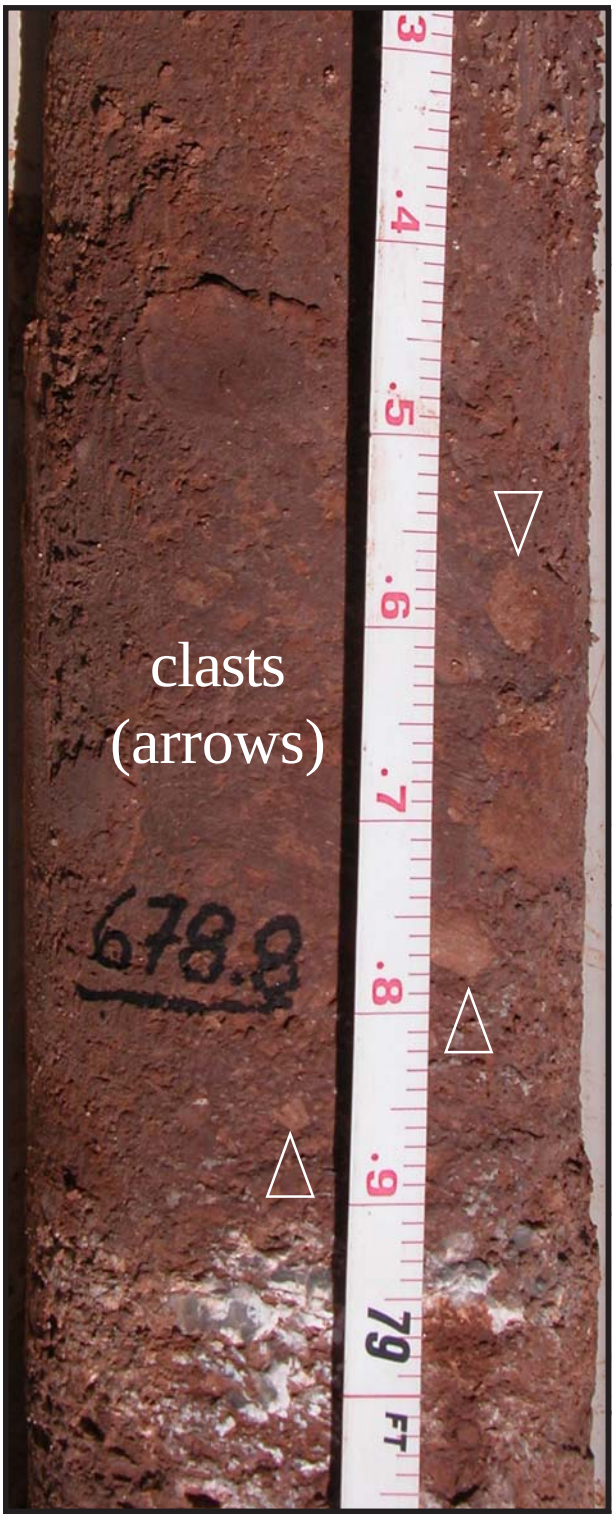


Formal and informal Rustler Formation units and depths at SNL-5 based on natural gamma log; below the gamma log, drilling depths have been modified to correspond to the basal contact of the Culebra on the geophysical log.

Figure 2-3. Thin, Compound Sulfate Bed and Clear Halite, Upper H-1

Figure 2-4. Reddish-Brown Siltstone and Sulfate Overlying Halite (H-1)

Figure 2-5. Subround Siltstone Clasts in Reddish-Brown Siltstone From Uppermost M-1.



The informal unit *anhydrite 1* (A-1; Fig. 2-2) was encountered from 665.3–674.8 ft (driller's depth). The thickness of A-1 at SNL-5 is slightly less than was encountered in SNL-2, further southwest (Powers and Richardson, 2004). At SNL-2, A-1 comprises three units: two sulfates and a thin siltstone. It requires further examination of logs and cores to determine whether the lower thin sulfate and siltstone of A-1at SNL-2 are equivalent to the siltstone and thin sulfate from 674.8–679.9 ft at SNL-5.

A-1 at SNL-5 is mainly fine-grained gray anhydrite with thin beds and fine laminae. Coarse gypsum occurs at the top of A-1. Two zones with reddish color are present. The lower reddish colored zone may correspond to a polyhalitic interval noted southeast of the WIPP site (Holt and Powers, 1988). The upper reddish zone may be due to infiltrated clay and fines from the overlying clastic unit.

The informal unit *mudstone-halite 2* (M-2/H-2; Fig. 2-2) was encountered from 657.9–665.3 ft bgl, based on coring depths, and recovery was complete. The natural gamma log shows the top of M-2/H-2 at 660 ft (Fig. 2-1). The basal contact with A-1 is sharp and slightly undulating. The contact between M-2 and Culebra was not recovered as continuous core, but the upper M-2 does not appear deformed.

The lower 6.3 ft of core is weak red (10R4/2) siltstone with some gray mottling and numerous gypsum and anhydrite clasts that are commonly subangular (Fig. 2-6) and float in finer clastic matrix. The upper part of this interval displays purple hues in the transition to the overlying gray claystone. Diagonal fractures and some bedding plane separations are filled with fibrous gypsum.

The upper 1.1 ft of M-2 consists of light brownish- gray claystone (2.5Y6/2) that shows some surface evidence of bedding and laminae. There is no evidence of sulfate in this zone.

Figure 2-6. Angular to Subround Sulfate Clasts and Fracture Fill in Lower M-2.

2.2.1.2 Culebra Dolomite Member

Based on the natural gamma log from SNL-5, the Culebra extends from 637–660.0 ft bgl, a thickness of 23 ft (Fig. 2-1). Based on drilling depths available at the time, the recovered Culebra core was marked from 634.8–657.9 ft bgl (as used in information in Appendices C and G). Recovered Culebra core (Fig. 2-7) totals 23.1 ft thick, and this represents all of the unit.

Holt and Powers (1988) found a range of 20–30 ft thickness in Culebra cores described from the WIPP project, and a regional thickness exceeding 40 ft, based on geophysical log data. Significant core loss in the middle of the Culebra is common because of the porosity of that zone. The excellent recovery of core at SNL-5 is likely due to less porosity at SNL-5, although somewhat different drilling techniques (mainly using compressed air) may have contributed.

The dolomite recovered in core from SNL-5 is generally light gray (5Y7/2) with brownish zones, and it is thin bedded to laminar (Fig. 2-7). Vugs are variable in size, ranging to 3 inches. Gypsum is more common below 650 ft. Short subvertical fractures and slight brecciation are apparent below 653 ft.

The basal hydrostratigraphic unit (CU-4) proposed for the Culebra by Holt (1997) is likely represented by the laminated and slightly deformed features in fragmented core from 656–657.9 ft.

From 645.6–656 ft, the Culebra shows thin (~0.25 inch) laminar zones spaced at 2–6 inches and abundant small pores (~0.06–0.25 inch). A few pores as large as 1 inch are scattered through the interval. Below 650 ft, some high-angle fractures are filled with gypsum. This interval is tentatively correlated with CU-3 (Holt, 1997).

From 639.3–645.6 ft, the dolomite has a more uniform gray color, but the porosity divides the section into two parts. From 641–645.6 ft, pores are less abundant, and there appears to be more pores filled with silt than in the higher dolomite. There is some gypsum along fracture surfaces. From 639.3–641 ft, small (< 0.125 inch) pores are abundant in bedded to laminar dolomite. Some vugs appear filled with gypsum and silt. This is likely the

most porous section of the Culebra. The entire interval is tentatively assigned to CU-2 (Holt, 1997).

From 634.8–639.3 ft, the dolomite is fine grained, silty, thin bedded to laminar, with organic-rich laminae at the top. Vugs are limited and large (to 3 inches). A high-angle fracture with no filling was intercepted from 637.3–637.9 ft. This interval corresponds to CU-1 (Holt, 1997).

The geophysical logs (Fig. 2-1) of the Culebra provide few additional details of the unit. The natural gamma shows some variations in the middle that generally correlate with core descriptions of silty zones. Electric logs indicate modest increases in resistivity upward through the unit, with little detailed structure. The neutron log shows an increase in the basal 6–7 ft that is consistent with less porosity through part of the zone. Overall, there is not a great contrast in properties through the Culebra, and the Culebra is not likely to have either high porosity or high transmissivity.

2.2.1.3 Tamarisk Member

The natural gamma log of SNL-5 shows that the Tamarisk occurs from 540–637 ft bgl. The Tamarisk comprises three basic subunits: a lower anhydrite, a middle mudstone to halite, and an upper anhydrite; all three are clearly shown by geophysical logs and were recorded by cuttings 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-5 is located in the mudflat or M-3 facies of these beds. The basal 36.8 ft and upper 7.3 ft of the Tamarisk were cored; 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 16 ft thick (621–637 ft) based on the geophysical logs. Core retained from the interval was marked from 618.3–634.8 ft, an interval thickness of 16.5 ft. A-2 is predominantly gray gypsum, with some anhydrite as well as thin claystone interbeds.

The basal contact with the Culebra (Fig. 2-7) grades over ~ an inch. The upper contact is gradational over ~2 inches. Bedding is horizontal, but poorly displayed, through most of A-2. Near the top of A-2, bedding is inclined ~20-30 degrees. Gray siltstone and clay, with gypsum-filled fractures, occurs from 624.5–624.8 ft. The gypsum of A-2 is reddish from 628–629 ft.

The informal Tamarisk unit *mudstone-halite 3* (M-3/H-3; Fig. 2-2) is 9 ft thick (612–621 ft bgl) at SNL-5, based on the natural gamma. No halite (H-3) is present at SNL-5. The cored interval for M-3 is marked from 611.2–618.3 ft, which is about 2 ft less than the natural gamma. The complete interval appears to have been recovered in cores. The caliper log shows an enlarged diameter through most of M-3. The natural gamma was also likely responding to silt and clay in the basal part of A-3 overlying M-3.

M-3 is dominantly reddish-brown (2.5YR4/4) siltstone and claystone with some gray reduction zones. It is not as clearly color stratified as in other drillholes, such as SNL-3. Angular gypsum clasts to 3 inches diameter are preserved in the upper 1.3 ft. Smaller intraclasts occur from 614–615.8 ft. Small fractures in M-3 are filled with gypsum.

The informal unit *anhydrite 3* (A-3; Fig. 2-2) occurs from 540–612 ft bgl on geophysical logs, a thickness of 72 ft, which is thicker than at the WIPP site. Core from the bottom and top of A-3 have contacts marked at 538.7 and 611.2 ft, implying a thickness of 72.5 ft. The main part of A-3 was drilled.

The basal part of A-3 (13.2 ft) was cored, and this part of the unit is mainly gray anhydrite with some coarse, clear gypsum. This part of A-3 is bedded to laminar, with wavy to inclined beds (dips generally <15°) at 605 ft. Below 605 ft, bedding is more inclined and brecciated, especially from 608–611.2 ft. Blocks near the base are large, and some gray claystone, as well as a siltstone clast, are included. This zone likely contributes to the gamma signature associated with the underlying M-3.

The upper 3.3 ft of A-3 were cored and show laminated to thin bedded, dark gray, fine gypsum

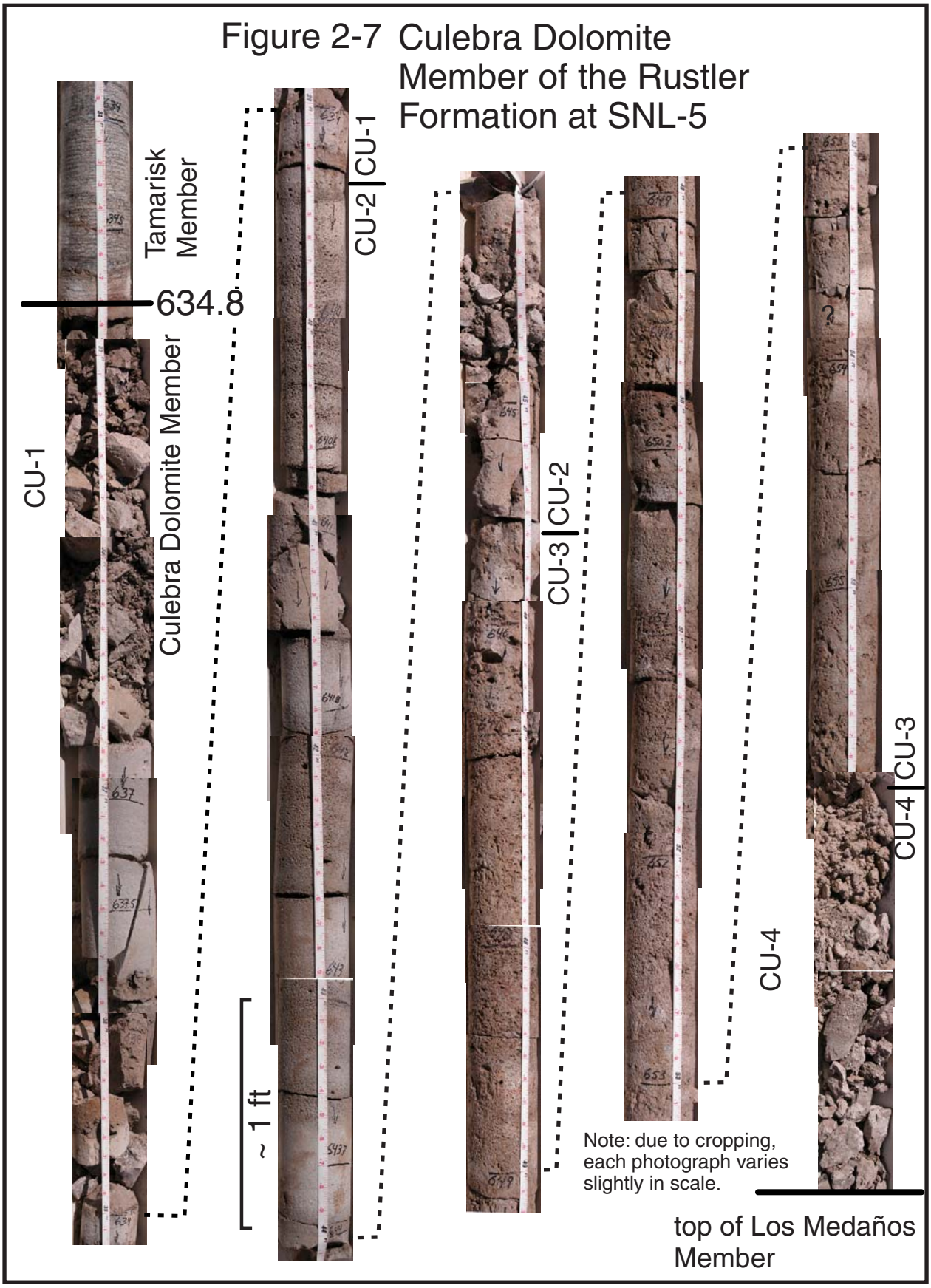


Figure 2-7 Culebra Dolomite Member of the Rustler Formation at SNL-5
Tamarisk Member
634.8
Culebra Dolomite Member
CU-1
CU-1
CU-2
CU-2
CU-3
CU-3
CU-4
CU-4
~ 1 ft
Note: due to cropping, each photograph varies slightly in scale.
top of Los Medaños Member

and anhydrite. There are some nodular features near the top. The transition to the Magenta is sharp in core, although a few thin beds in the core indicate some earlier carbonate or organic sediment.

Most of A-3 was not cored. The cuttings from drilling are generally good, and they are consistent with dark gray anhydrite showing some bedding. The geophysical logs for A-3 show an unusual high gamma signature from 590–595 ft. The intensity of the natural gamma is similar to other clastic and organic-rich units and is less than is generally expected for a potassium-bearing sulfate such as polyhalite. Polyhalite is present in some drillholes east and south of the WIPP site center in H-3. The caliper log does not show evidence of drillhole enlargement that commonly occurs in strongly argillaceous zones. It is likely that a local organic-rich zone, possibly algal in origin, trapped the minerals providing a gamma source.

The Tamarisk stratigraphy and thickness are generally consistent with other drillholes and shafts in the area (Holt and Powers, 1988), although A-3 is somewhat thicker. The high natural gamma in A-3 is unusual, and further investigation of cuttings and records from other drillholes may provide a specific explanation.

2.2.1.4 Magenta Dolomite Member

Based on geophysical logs, the Magenta at SNL-5 is 24 ft thick (516–540 ft). Core from the Magenta is marked from 514.3–538.7 ft, a thickness of about 24.4 ft (Fig. 2-8). Recovery was complete, with little fragmentation.

The Magenta consists of gypsiferous dolomite and gypsum, and it is commonly gray to grayish brown at SNL-5. The reddish-purple color for which the Magenta is named occurs in outcrop and apparently is a consequence of weathering. The dominant characteristic of the Magenta in cores from SNL-5, like outcrops and shaft exposures of the Magenta, is strong wavy to laminar bedding.

From 537.5–538.5 ft, wavy and thin beds have higher amplitudes indicating algal growth (Fig. 2-8). Low-angle cross-cutting relationships are more common higher in the Magenta. A zone from 516–519.2 ft appears to have more organic-rich thin laminae. A thin nodular gypsum is present from 520.6–520.8 ft, and nodular zones occur from 521.6–522.5 ft and 528–529 ft. Gypsum-filled separations occur from 533.7–536 ft. High-angle gypsum-filled fractures were cored from 529–532 ft.

The dolomite appears most porous from 516–520.5 ft, and there is little evidence of sulfate through this interval. This zone is stratigraphically similar to more porous zones in other drillholes though the interval is not as thick as in other drillholes. Geophysical logs do not indicate strong differences in porosity through the Magenta.

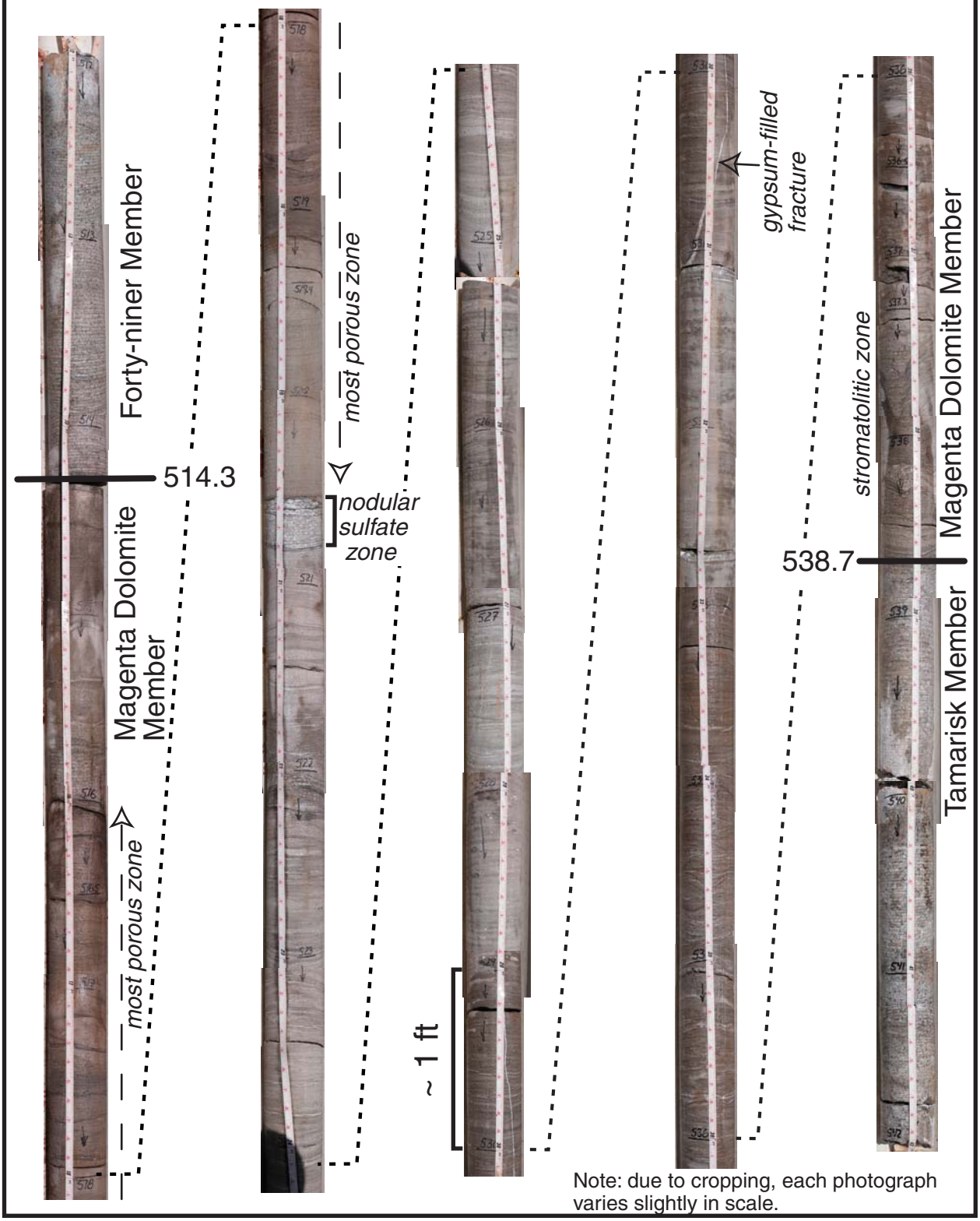
The Magenta is typical in thickness, composition, and sedimentary features. The more porous zone in the upper Magenta is consistent in stratigraphic position with porous zones in many other Magenta cores, although the porosity may not be great. The Magenta is less fractured at SNL-5 than it is at SNL-2, near Livingston Ridge.

2.2.1.5 Forty-niner Member

The Forty-niner at SNL-5 is 61 ft thick (455–516 ft), based on geophysical logs. A change in drilling rates was also noted at 455 ft, consistent with the logging depths for the top of the Forty-niner. The Forty-niner is described on the basis of cuttings and geophysical logs through the upper part of the member to the coring depth beginning at 498 ft. All Forty-niner coring took place in the lower sulfate bed of the member. Like the Tamarisk, the Forty-niner consists of upper and lower anhydrites with a middle unit that ranges from claystone at SNL-5 to halite east of the WIPP site area. 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 white to gray, coarse to fine anhydrite and gypsum. A-4 is 17 ft thick (499–516 ft), based on geophysical logs. The interval from drilling and coring is from 497–514.3 ft, a thickness of 17.3 ft.

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



Note: due to cropping, each photograph varies slightly in scale.

Figure 2-9
Core Photograph of Nodular Sulfate in Upper Magenta

The recovered core of A-4 from 512–514.3 ft includes thin carbonate laminae and beds. This section was placed stratigraphically in A-4 instead of the Magenta because of the dominance of gypsum and because of the continuous dolomite below 514.3 ft (as marked on the core).

Mudstone-halite 4 (M-4/H-4; Fig. 2-2) is about 15 ft thick (484–499 ft), based on the natural gamma log. Cuttings returns and drilling rates indicating clastics from about 484–497 ft are consistent with the geophysical log. Cuttings from M-4 showed a lower (492–497 ft) light brownish-gray (10YR6/2; wet) argillaceous siltstone that is not calcareous. From 484–492 ft, reddish-brown (2.55YR5/3; wet) argillaceous siltstone and sandstone were recovered. This unit also is not calcareous. No halite was observed in cuttings, nor was any indicated by geophysical log signatures.

The upper sulfate unit, *anhydrite-5* (A-5), is gray (5YR6/1) gypsum and anhydrite composed of fine crystals. It is 29 ft thick (455–484 ft bgl) at SNL-5.

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-5, the Dewey Lake is 419 ft thick (36–455 ft bgl) and is composed mainly of red (2.5YR5/6; wet) (2.5YR4/6; dry) interbedded sandy siltstone, argillaceous siltstone, and fine-grained sandstone. Small white (5YR6/1) reduction spots and zones are a common characteristic of the Dewey Lake and are recorded by the cuttings at SNL-5. The Dewey Lake is noncalcareous to very calcareous from 36 ft to ~207 ft. Below 207 ft, the Dewey Lake is gypsiferous. The Dewey Lake is described on the basis of cuttings, drilling rates, and geophysical log characteristics.

Geophysical logs from SNL-5 can be 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).

Only the lower two of three general depositional regimes for the Dewey Lake Formation can be clearly distinguished on natural gamma logs of SNL-5. The base of the third may be preserved.

The interval from 347–455 ft bgl in SNL-5 displays the natural gamma and resistivity features of the lower Dewey Lake informally called the *basal bedded zone* (Powers, 2003b). The natural gamma fluctuates around a similar value (~ 70 cps in this case) over this vertical interval. There are zones of lower gamma, but there are no apparent trends over the entire interval. The resistivity and induction logs tend to fluctuate as well, on a vertical scale of ~4–40 ft. The fluctuations are too coarse to correlate with other boreholes as is possible in some logs. The patterns are consistent with broad scale bedding, and the interval corresponds to a bedded section clearly exposed in the air intake shaft (Holt and Powers, 1988).

The interval from 36–347 ft bgl (311 ft thick) is marked by generally upward-increasing gamma above thinner low gamma units. 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 a sandstone unit from ~335–347 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 SNL-5, at SNL-2, sandstones of the upper fining-upward cycles are removed by erosion.

The natural gamma log through the fining-upward cycles shows a marked decrease over intervals from 101–106 ft and 57–64 ft, corresponding to very fine to medium-grained sandstones found across the site area (Powers, 2003b). The sand grains from the lower unit are typically subangular to well rounded and include few opaque grains. This unit corresponds to sandstone 1 (*ss1*), a persistent sandstone in this stratigraphic interval (Powers, 2003b). The upper sandstone is less persistent across the area.

The natural gamma decreases above 40 ft. Based on cuttings, the top of the Dewey Lake was placed at 36 ft. This thin interval is tentatively attributed to the third sequence, a slight coarsening-upward cycle at the top of the Dewey Lake in drillholes to the east of this area. Nevertheless, it is possible that the gamma is indicating top of Dewey Lake at 40 ft and that the cuttings are not as precise. The difference is not significant.

The broad sedimentological units definable by natural gamma logs for the Dewey Lake are present and are generally representative below 40 ft.

Cuttings from the upper Dewey Lake were calcareous to a depth ~207 ft. Below 207 ft, cuttings included gypsum and were non-calcareous. The induction log shows an increase at ~206 ft, where gypsum was encountered. The resistivity also displays an increase from 230–310 ft that is only partially reflected by increases in gypsum in the cuttings. The neutron flux and density logs are not helpful in defining the change in mineralogy at ~207 ft.

The boundary between carbonate (above) and sulfate (below) in the Dewey Lake at ~207 ft is stratigraphically high in the Dewey Lake and compares to observations near the center of the WIPP site (e.g., Holt and Powers, 1988). This position contrasts with observed lower cement changes in some other drillholes in the southern part of the WIPP site and along Livingston Ridge (Powers, 2002b, 2003b).

On the basis of the resistivity log (Fig. 2-1) and by comparison with other similar situations, the Dewey Lake is likely to be more transmissive above ~207 ft, at or near the carbonate–sulfate boundary.

2.2.3 Miocene-Pleistocene Gatuña Formation

The Gatuña at SNL-5 is about 29 ft thick (7–36 ft). It is mainly sandstone that is very calcareous and ranges from pink (5YR7/3) to yellowish red (5YR5/6). It becomes darker with depth as carbonate infiltrating from the Mescalero decreases. The sandstone includes fragments of some green chert pebbles; and a hard drilling zone was encountered from 11–12 ft. There are some rare manganese oxide stains, similar to findings in broader studies of the Gatuña (Powers and Holt, 1993).

2.2.4 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 southwest of SNL-1 along Livingston Ridge (Izett and Wilcox, 1982).

At SNL-5, the Mescalero is ~3 ft thick (7–4 ft). From cuttings, the Mescalero is a white (10YR8/1), very calcareous sandstone to sandy limestone. Sand grains were fine to medium, subangular to subround.

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-5.

2.2.4 Surficial Deposits

Construction fill is about 1 ft thick at the drillhole location. The surface materials under the fill consist of pinkish gray (7.5YR6/2; damp) sand that is very calcarous and was somewhat moist. The Berino soil (Chugg and others, 1971) was not established at SNL-5.

3.0 PRELIMINARY HYDROLOGICAL DATA FOR SNL-5

SNL-5 was drilled specifically to monitor water levels and water quality from the Culebra Dolomite Member of the Rustler Formation, to serve as a location for observations during pumping tests, and as a possible pumping well for a multi-well test north of the WIPP site.

3.1 Checks for Shallow Groundwater Above the Rustler Formation

Damp cuttings were encountered above the Mescalero caliche, which are attributed to the slightly lower area at SNL-5 and rainfall in early April 2004.

Below the Mescalero, through the Dewey Lake, and to the coring point at 512 ft above the Magenta, there were no indications of water flowing into the drillhole.

The hole was drilled with compressed air and a small volume of water with some Quik-Foam® added. Before drilling began each morning, an electric probe was lowered into the drillhole through the drilling pipe to a point a few feet above the bit. In addition, the return air was observed as drilling commenced to check for water that might have been undetected at the level of the drill bit.

3.2 Initial Results From the Magenta Dolomite

Compressed air with a small amount of fresh water and Quik-Foam® was used to core SNL-5 through the Magenta and drill on to 556 ft on May 3, 2004. There were no direct observations of fluid inflow through this interval. On May 4, 2004, an electric probe run inside the drill pipe to 542 ft before drilling began did not detect any water in the drillhole.

On May 4, SNL-5 was drilled and cored into A-2, ~7.5 ft above the Culebra. The drillhole remained open overnight, and an electric probe was run into the open hole without detecting any water to 627 ft.

3.3 Initial Results From the Culebra Dolomite

The Culebra and upper Los Medaños were cored to a depth of 687.3 ft on May 5. On the morning of May 6, the water level in the drillhole was at 330 ft bgl. The cored interval from 598 ft to 674 ft was reamed to a diameter of 11 inches on May 6. On May 7, SNL-5 was logged, and the water level in the drillhole was 325 ft bgl, ~312 ft above the top of the Culebra.

On May 10, the FRP casing was placed in the hole, and the well was completed for Culebra testing and monitoring.

After the well was completed, the Culebra was developed to prepare it for future testing and monitoring. On May 11, 2004, 180 barrels of water were used to jet the FRP casing at SNL-5 to clean out the casing and screen. On May 19, 2004, a pump was installed in SNL-5, and the pump was run to pump and backwash for 7 hours at rates from 5 gpm to 12 gpm, producing clear water by the end of pumping.

On May 20, 2004, SNL-5 was pumped and backwashed for 6.75 hours at rates from 12 gpm at the beginning to 5 gpm at the end. The final specific gravity was 1.006 g/cc. A total of 3,600 gallons of water was pumped from SNL-5.

Static water levels for the Culebra in SNL-5 are now being measured. The initial measurement on June 6, 2004, was a depth of 313.6 ft bgl, corresponding to an elevation of 3,068.28 ft amsl and a fresh-water equivalent level of 3,070.30 ft amsl (Siegel, 2004a). Comparable water level measurements were not made in July and August due to pumping tests. Depth to water was measured on August 13, 2004, at 313.6 ft bgl, corresponding to an elevation of 3,068.33 ft amsl and a fresh-water equivalent elevation of 3,070.35 ft amsl (Siegel, 2004b) (Table 3-1; Fig. 3-1).

Table 3-1
Culebra Water Levels Measured In SNL-5

Date	Time (MDT)	Depth (ft) to water level	Water Elevation (ft amsl)	
			Measured	Fresh-water Equivalent
06/07/04	12:48	313.60	3068.28	3070.30
	No July measurement due to pump test			
	No August measurement due to pump test			
09/13/04	10:50	313.55	3068.33	3070.35

Source: Siegel, 2004a,b.Measuring point reference for depth is 3381.88 ft amsl.

Figure 3-1
Culebra Water Elevation at SNL-5

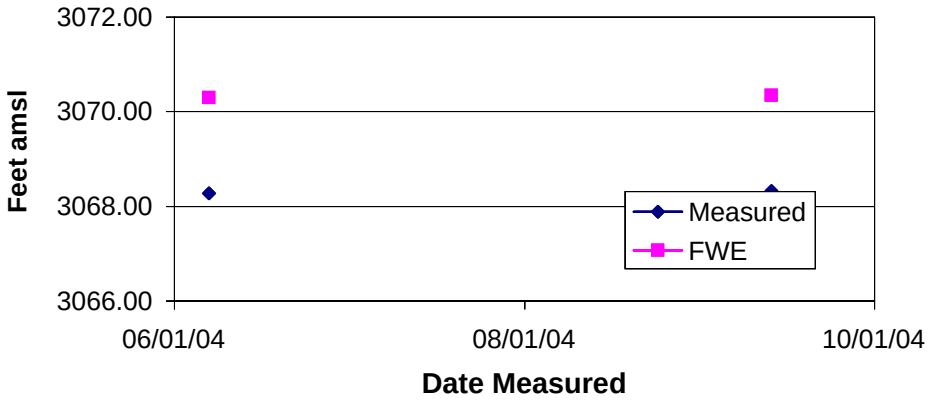


Figure 3-2. SNL-5 Configured for Continuous Water Level Monitoring. The wellhead is set up with a pump and a mini-Troll installed to continuously monitor water levels. Photo taken June 21, 2004, by Dennis W. Powers.

4.0 SIGNIFICANCE/DISCUSSION

The materials used in completing SNL-5 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-5. Previous studies of thickness changes between the Culebra and Vaca Triste Sandstone Member of the Salado Formation (Powers, 2002a, 2003a; Powers and others, 2003) indicated that SNL-5 was located considerably east of the margin where upper Salado halite has been dissolved (Fig. 4-1). SNL-5 was located east of the margin of halite in M-1/H-1, where halite was expected in this part of the lower part of the Los Medaños (Fig. 2-2). Halite was recovered from cores in the upper M-1/H-1 interval, as expected. Interpolated Culebra elevations in the area of SNL-5 will be revised by the data from the drillhole (Fig. 4-2).

In contrast to SNL-2 to the southwest of SNL-5, halite rock was encountered in the upper part of M-1/H-1. At SNL-2, halite occurred as a cement in the middle and lower siltstones and fine sandstones of this part of the Los Medaños. No halite rock was recovered from SNL-2. Core loss in SNL-2 of up to 15 ft through this interval prevents direct comparison, although the relationships through cores and geophysical are likely to be reexamined in later detailed studies.

The uppermost Los Medaños (M-2/H-2) does not include halite at SNL-5. This is consistent with halite margins as previously estimated for this unit (Powers, 2002a, 2003a) and a depositional origin for mudstone-halite facies. Although the contact with the overlying Culebra was not recovered as continuous core, the upper part of M-2 did not display much deformation, such as has been found in some other drillholes.

Culebra core recovery was exellent. One reason may be the apparent lesser porosity at SNL-5 compared to many other drillhole locations. In addition, the drilling methodology, using mainly compressed air rather than circulating drilling fluid, may also have contributed to the success in core recover. At SNL-5, pores or vugs were less abundant than in most cores from the Culebra, and much of the small pores appeared filled by silt. Fracturing was limited, and the unit overall will likely have low transmissivity.

The Magenta core showed some slight porosity through an interval in the upper part of the Magenta. There is little difference in resistivity through the Magenta that corresponds to core differences. There were no indications during drilling of water inflow from the Magenta.

Cuttings and resistivity changes suggest that the change in natural mineral cements of the Dewey Lake is ~207 ft bgl. This position is comparable stratigraphically to its position 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 saturated zone at this boundary in SNL-5, or in any other part of the Dewey Lake. Changes in resistivity suggest several porosity changes in the Dewey Lake.

The Gatuña is ~29 ft thick at SNL-5. To the east, at SNL-3, the unit is much thicker, and it appears to be part of valley fill in the area as outlined by Bachman (1985). As SNL-5 is along the trend of the valley fill outlined by Bachman, it was possible that SNL-5 would have more than 29 ft of Gatuña. If a paleovalley is present, it's morphology is complicated, with deeper and shallower portions.

Drillhole data are sparse near SNL-5. Elevation data for the Culebra in the vicinity led to interpolated structure contours indicating that the top of Culebra at SNL-5 would have an elevation of ~2674 ft amsl (815 m; Fig. 4-2A). Based on a surface reference

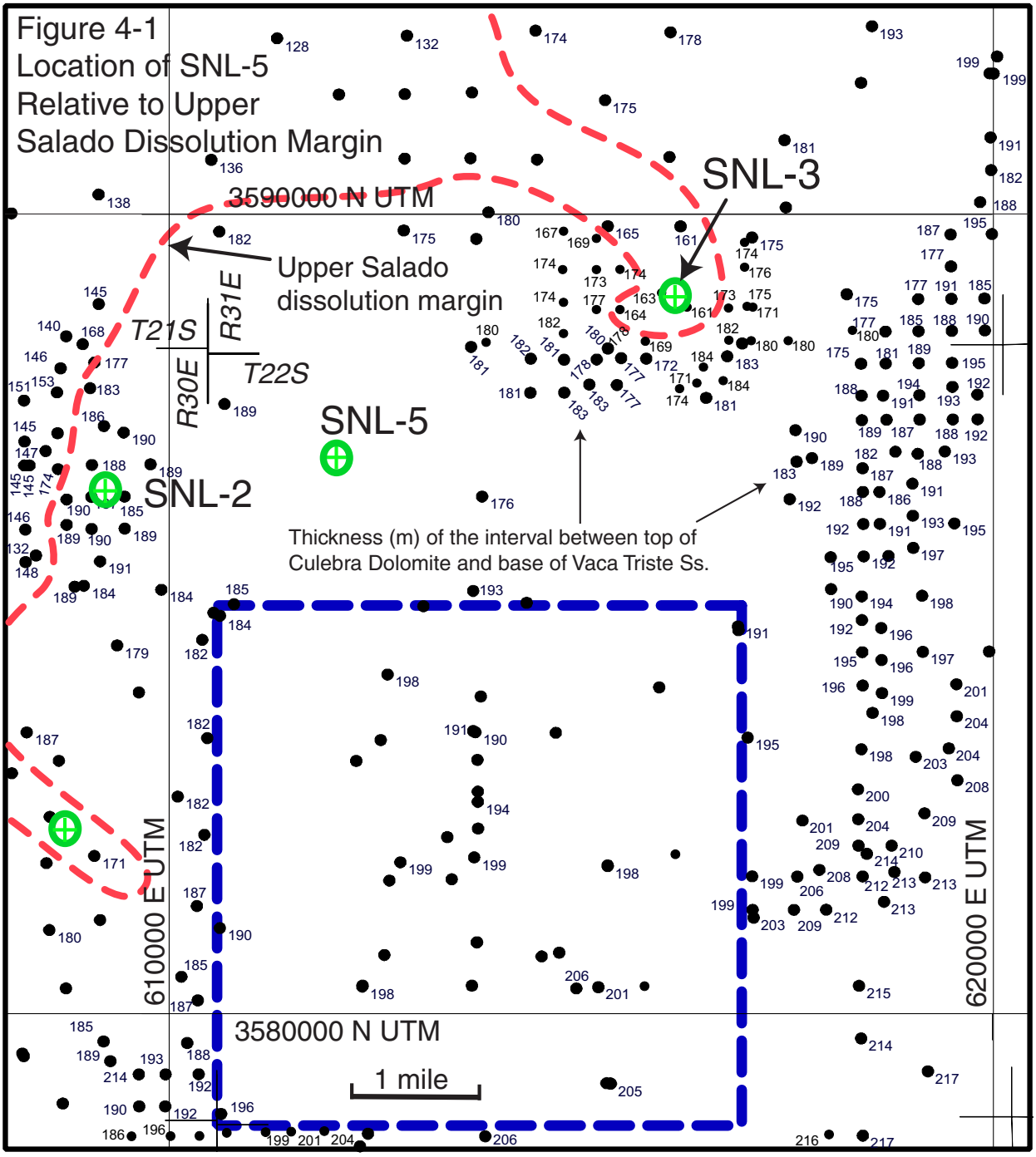
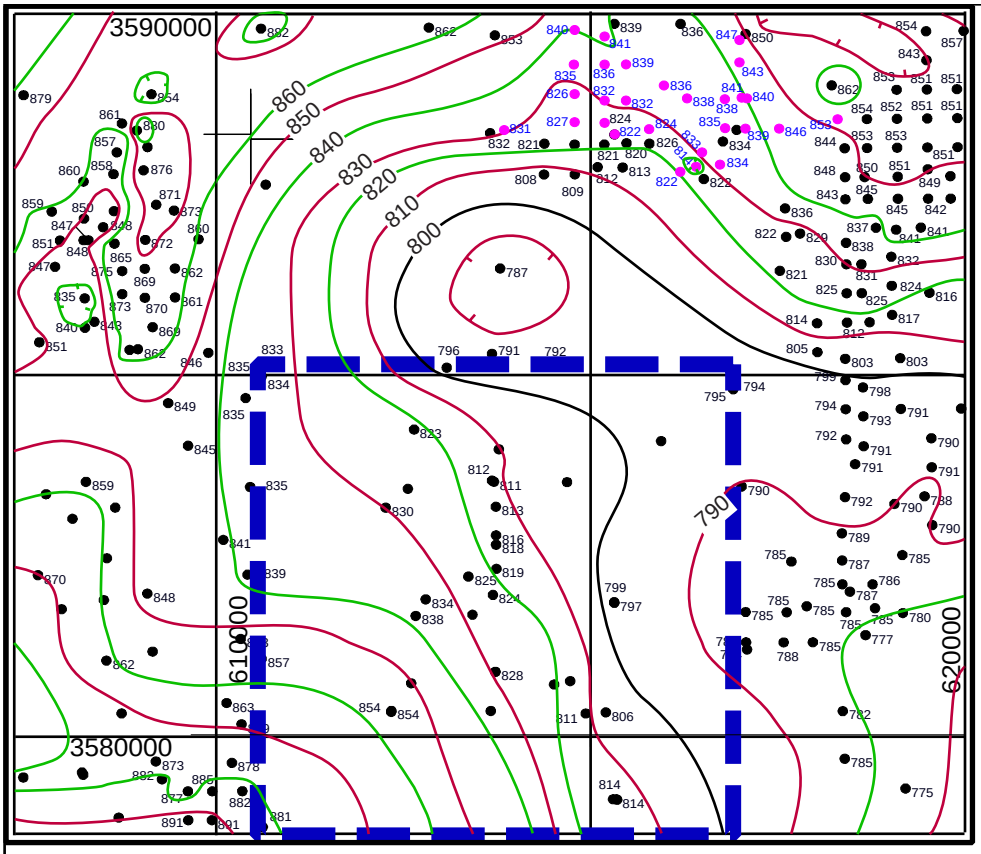
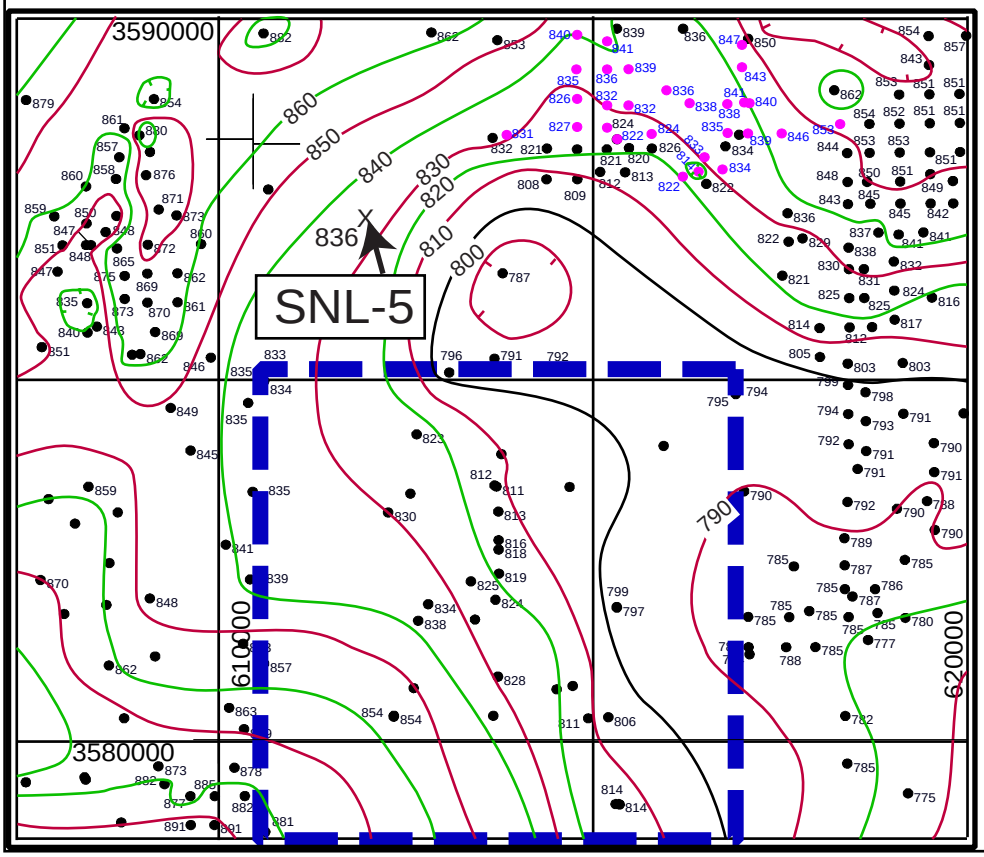


Figure 4-1
Location of SNL-5
Relative to Upper
Salado Dissolution Margin
3590000 N UTM
Upper Salado
dissolution margin
SNL-3
SNL-5
SNL-2
T21S
T22S
R30E
R31E
Thickness (m) of the interval between top of
Culebra Dolomite and base of Vaca Triste Ss.
610000 E UTM
620000 E UTM
3580000 N UTM
1 mile



A. Before Drilling



B. After Drilling

Figure 4-2 Elevation of Culebra Dolomite Near SNL-5 (meters amsl)

elevation of 3380 ft amsl and a depth of 637 ft, the top of Culebra has an elevation of ~2743 ft amsl (836 m), nearly 70 ft higher than was estimated. This indicates that the syncline trending southeast-northwest does not stretch as far to the north (Fig. 4-2B) as was interpolated in this area with no close controls. The synclinal structure is principally an artifact of eastward general dip to the Culebra and the deformation into an anticline trending southeast-northwest. This anticline is an expression of deeper deformation of evaporites in the lower Salado and upper Castile Formations.

5.0 REFERENCES CITED

Bachman, G.O., 1973, Surficial Features and Late Cenozoic History in Southeastern New Mexico: U.S. Geological Survey Open-file Report USGS-4339-8, 32 p.

Bachman, G.O., 1985, Assessment of Near-Surface Dissolution at and near the Waste Isolation Pilot Plant (WIPP), Southeastern New Mexico: SAND84-7178, Sandia National Laboratories, Albuquerque, NM.

Bachman, G.O., and Machette, M.N., 1977, Calcic Soils and Calcretes in the Southwestern United States: U.S. Geological Survey Open-file Report 77-794, 163 p.

Chugg, J.C., Anderson, G.W., Kink, D.L., and Jones, L.H., 1971, Soil Survey of Eddy Area, New Mexico: U.S. Department of Agriculture, 82 p plus figures.

Doveton, J.H., 1986, Log Analysis of Subsurface Geology: John Wiley & Sons, New York, NY, 273 p.

Hills, J.M., and Kottlowski, F.E. (coordinators), 1983, Southwest/Southwest Mid-Continent Region: American Association of Petroleum Geologists, Correlation Chart Series.

Holt, R.M., 1997, Conceptual Model for Transport Processes in the Culebra Dolomite Member, Rustler Formation: SAND97-0194, Sandia National Laboratories, Albuquerque, NM.

Holt, R.M., and Powers, D.W., 1988, Facies Variability and Post-Depositional Alteration Within the Rustler Formation in the Vicinity of the Waste Isolation Pilot Plant, Southeastern New Mexico: WIPP DOE 88-004, U.S. Department of Energy, Carlsbad, NM, 88221

Holt, R.M., and Powers, D.W., 2002, Impact of Salt Dissolution on the Transmissivity of the Culebra Dolomite Member of the Rustler Formation, Delaware Basin, Southeastern New Mexico: Abstracts with Programs, Geological Society of America, v. 34, no. 6, p. 203.

Holt, R.M., and Yarbrough, L., 2002, Analysis Report, Task 2 of AP-088, Estimating Base Transmissivity Fields. Copy on file in the Sandia National Laboratories WIPP Records Center under ERMS 523889.

Izett, G.A., and Wilcox, R.E., 1982, Map Showing Localities and Inferred Distribution of the Huckleberry Ridge, Mesa Falls and Lava Creek Ash Beds in the Western United States and Southern Canada: U.S. Geological Survey, Miscellaneous Investigations Map I-1325, Scale 1:4,000,000.

Lucas, S.G., and Anderson, O.J., 1993, Stratigraphy of the Permian-Triassic Boundary in Southeastern New Mexico and West Texas, *in* Hawley, J.W., and others, eds., Geology of the Carlsbad Region, New Mexico and West Texas: 44th NMGS Fall Field Conference Guidebook, New Mexico Geological Society, Socorro, NM, p. 219-230.

Mercer, J.W., Cole, D.L., and Holt, R.M., 1998, Basic Data Report for Drillholes on the H-19 Hydropad (Waste Isolation Pilot Plant–WIPP): SAND98-0071, Sandia National Laboratories, Albuquerque, NM.

Powers, D.W., 2002a, Analysis Report, Task 1 of AP-088, Construction of Geologic Contour Maps. Copy on file in the Sandia National Laboratories WIPP Records Center under ERMS 522085.

Powers, D.W., 2002b, Basic Data Report for Drillhole C-2737 (Waste Isolation Pilot Plant – WIPP): DOE/WIPP 01-3210, U.S. Department of Energy, Carlsbad, NM, 88221.

Powers, D.W., 2003a, Addendum 2 to Analysis Report Task 1 of AP-088, Construction of Geologic Contour Maps. Copy on file in the Sandia National Laboratories WIPP Records Center under ERMS 522085.

Powers, D.W., 2003b, Test Plan, TP 02-05 Geohydrological Conceptual Model for the Dewey Lake Formation in the Vicinity of the Waste Isolation Pilot Plant (WIPP): Sandia National Laboratories.

Powers, D.W., and Holt, R.M., 1993, The Upper Cenozoic Gatuña Formation of Southeastern New Mexico, *in* Hawley, J.W., and others, eds., Geology of the Carlsbad Region, New Mexico and West Texas: 44th NMGS Fall Field Conference Guidebook, New Mexico Geological Society, Socorro, NM, p. 271-282.

Powers, D.W., and Holt, R.M., 1999, The Los Medaños Member of the Permian Rustler Formation: *New Mexico Geology*, v. 21, no. 4, p. 97-103.

Powers, D.W., and Holt, R.M., 2000, The Salt That Wasn't There: Mudflat Facies Equivalents to Halite of the Permian Rustler Formation, Southeastern New Mexico: *Journal of Sedimentary Research*, v. 70, no. 1, p. 29-36.

Powers, D.W., Holt, R.M., Beauheim, R.L., and McKenna, S.A., 2003, Geological Factors Related to the Transmissivity of the Culebra Dolomite Member, Permian Rustler Formation, Delaware Basin, Southeastern New Mexico, *in* Johnson, K.S., and Neal, J.T., eds., Evaporite Karst and Engineering/ Environmental Problems in the United States: Oklahoma Geological Survey Circular 109, p. 211-218 .

Powers, D.W., and Richardson, R.G., 2004, Basic Data Report for Drillhole SNL-2 (C-2948) (Waste Isolation

Pilot Plant): DOE/WIPP 03-3290, U.S. Department of Energy, Carlsbad, NM.

Renne, P.R., Steiner, M.B., Sharp, W.D., Ludwig, K.R., and Fanning, C.M., 1996, $^{40}Ar/^{39}Ar$ and U/Pb SHRIMP Dating of Latest Permian Tephras in the Midland Basin, Texas: *EOS*, Transactions, American Geophysical Union, v. 77, p. 794.

Renne, P.R., Sharp, W.D., Montañez, I.P., Becker, T.A., and Zierenberg, R.A., 2001, $^{40}Ar/^{39}Ar$ Dating of Later Permian Evaporites, Southeastern New Mexico, USA: *Earth and Planetary Science Letters*, v. 193, p. 539-547.

Rosholt, J.N., and McKinney, C.R., 1980, Uranium Series Disequilibrium Investigations Related to the WIPP Site, New Mexico, Part II: Uranium Trend Dating of Surficial Deposits and Gypsum Spring Deposit near WIPP Site, New Mexico: U.S. Geological Survey Open-file Report 80-879, p. 7-16.

Sandia National Laboratories, 2003, Program Plan, WIPP Integrated Groundwater Hydrology Program, FY03-09, Revision 0. March 14, 2003. Copy on file in the Sandia National Laboratories WIPP Records Center under ERMS 526671.

Schiel, K.A., 1988, The Dewey Lake Formation: End Stage Deposit of a Peripheral Foreland Basin [unpublished M.S. Thesis]: El Paso, TX, University of Texas at El Paso, 181 p.

Schiel, K.A., 1994, A New Look at the Age, Depositional Environment and Paleogeographic Setting of the Dewey Lake Formation (Late Permian?): *West Texas Geological Society Bulletin*, v. 33, no. 9, p. 5-13.

Siegel, J., 2004a, Transmittal of the Water Level Data for June 2004: letter to Dr. Dave Kessel, Sandia National Laboratories, dated June 17, 2004, WRES:04:556, UFC:5480.00.

Siegel, J., 2004b, Transmittal of the Water Level Data for June 2004b: letter to Dr. Dave Kessel, Sandia National Laboratories, dated October 1, 2004, WRES:04:660, UFC:5480.00.

U.S. Department of Energy, 1996, Title 40 CFR Part 191 Compliance Certification Application for the Waste Isolation Pilot Plant: DOE/CAO-1996-2184, U.S. Department of Energy, Carlsbad, NM.

U.S. Department of Energy, 2004, Title 40 CFR Part 191 Subparts B and C Compliance Recertification Application for the Waste Isolation Pilot Plant: DOE/WIPP 04-3231, U.S. Department of Energy, Carlsbad, NM.

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.

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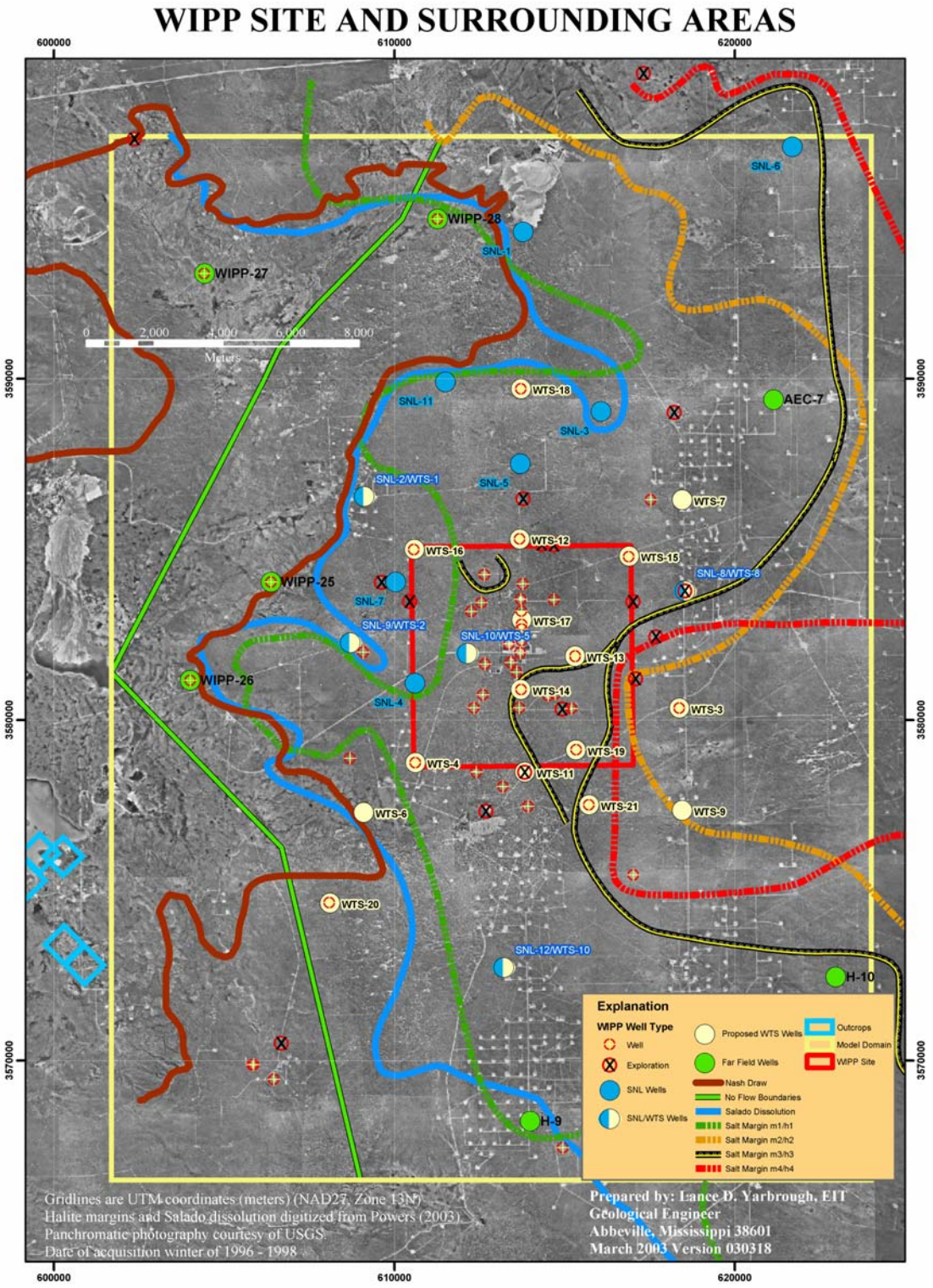
WIPP SITE AND SURROUNDING AREAS
600000
610000
620000
3590000
3580000
3570000
WIPP-28
WIPP-27
WIPP-25
WIPP-26
SNL-1
SNL-2/WTS-1
SNL-3
SNL-4
SNL-5
SNL-6
SNL-7
SNL-8/WTS-8
SNL-9/WTS-2
SNL-10/WTS-5
SNL-11
SNL-12/WTS-10
WTS-3
WTS-4
WTS-6
WTS-7
WTS-9
WTS-11
WTS-12
WTS-13
WTS-14
WTS-15
WTS-16
WTS-17
WTS-18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

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5. Description of Field Activities

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

5.1 New and Replacement Wells

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

5.1.1 SNL Well Justifications…

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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-5			X			X		

…

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SNL-5: Both Culebra and Magenta (and Dewey Lake if water is present at that horizon) wells will be installed at this location midway between existing wells DOE-2 and WIPP-30, north of the WIPP site (see Figure 8). This location is critical in understanding the distribution of Culebra transmissivity north of the WIPP site, along one of the two possible pathways for water from the Mississippi East tailings pile to be influencing heads at WIPP. DOE-2 lies in a high-transmissivity region of the Culebra, while WIPP-30 lies in a low-transmissivity region. However, WIPP-30 responds strongly to pumping at wells in the northern portion of the WIPP site, indicating a good hydraulic connection that is inconsistent with an extensive region of low transmissivity. SNL-5 will also be in an area near many oil, gas, and potash holes, which could potentially be serving as conduits for leakage. The primary purposes to be served by SNL-5 are:

1. provide transmissivity data in a key area north of the WIPP site;
2. determine vertical head gradients north of the WIPP site; and
3. provide a location for a large-scale (multipad) pumping test to provide transient data for calibration of the Culebra model north 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-5	DL?	M	C?		

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

…

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5.3.2 Multipad Pumping Tests …

Well SNL-9/WTS-2 will be the pumping well for the western multipad test, with observation wells as shown in Figure 18[not included]. Provided that it is able to produce at least approximately 5 gpm, SNL-5 will be the pumping well for the northern multipad test, with observation wells as shown in Figure 19. If SNL-5 does not have the needed pumping capacity, SNL-11, SNL-3, and WTS-12 (in that order) will be considered as potential fallback pumping wells for the test.

…

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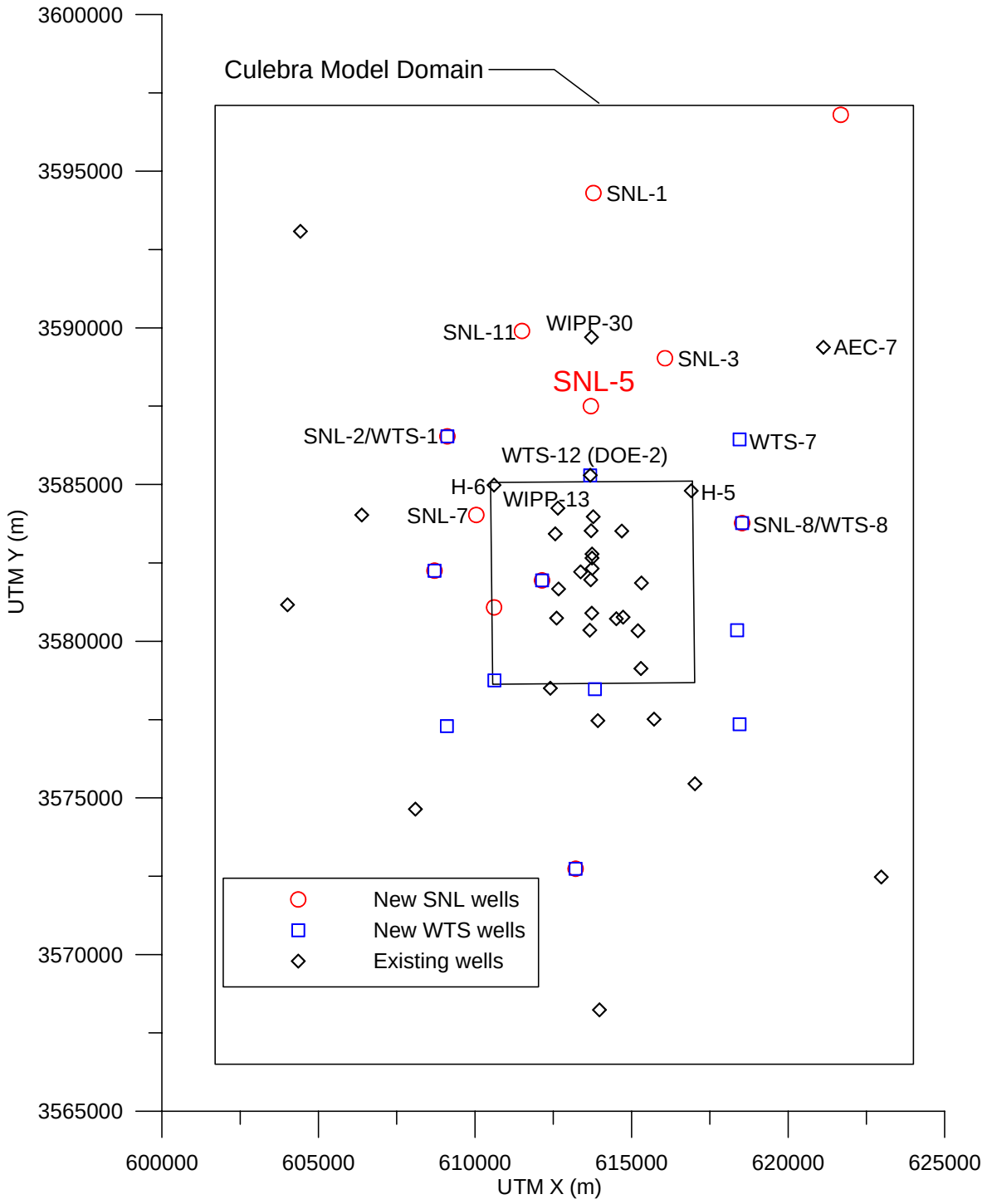

Figure 19. Pumping well and principal observation wells for northern multipad pumping test.

…

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Table 4. Expectations and Contingent Actions for New Wells.

Well	Expectations	Possible Actions if Expectations Not Met
SNL-5	• few—generally a characterization hole • Culebra T could be low to moderately high	• very high T (>10^{-4} m^2/s) or intense fracturing could lead to decision to deepen hole into upper Salado, alter conceptual model of Salado dissolution

…

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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-5	840	730	??

…

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7.3 Logging

Open-hole geophysical logging will be performed after each Culebra hole is drilled to total depth and reamed, but before the casing and well screen are installed. Wells drilled into the upper Salado will be logged prior to reaming, and caliper logging will be repeated after reaming. The suite of logs to be run in all wells includes: natural gamma, resistivity (induction if the well is not fluid-filled), neutron, density, and caliper. These logs will be used to confirm stratigraphic contact depths determined from core, and will aid in selecting final casing and screening depths. In addition, a high-resolution microresistivity log (e.g., FMI, FMS, EMI) will be run in the SNL-2 Culebra well to determine its effectiveness at identifying fractures and their orientations. If successful, a microresistivity log may be run in other holes. In the Magenta and Dewey Lake wells, only natural gamma and caliper logs are planned, although resistivity (or induction) and neutron logs could be required in Dewey Lake wells to resolve uncertainty about the zone of saturation. After well completion, an acoustic cement-bond log may be run to provide a baseline of cement conditions behind the well casing. The logger must provide all logs in both paper and digital form.

Prickly pear cactus bloom near SNL-5 drillpad.
Photo by Dennis Powers, May 7, 2004.

Appendix B
Abridged Borehole History

The abridged borehole history has been prepared by compiling information from driller's reports by West Texas Water Well Services (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.

4-26-04 Left Odessa, TX, at 06:50 CDT (*see note above*) and arrived at SNL-5 drillpad site at 08:50. Conducted safety meeting. Rigged up 18" bit from 09:05 to 10:00. *Received word that compressor being delivered from rental company was involved in accident. Replacement coming from Farmington and will not arrive until late. Shut down generator. Safety inspection at 14:15.* On standby for compressor; *crew returned to Odessa*.

4-27-04 Departed Odessa at 07:00, arrived on site at 09:00. Held safety meeting. *Discussed results of safety inspection and addressed concerns.* On standby for compressor until 10:20. Rigged up compressor. Began drilling 18" hole at 10:35. *Began using mist* (used 1 quart of soap) *at 13*'; *additional compressor will be brought in tomorrow to continue with air.* Reached 25' at 12:15, broke for lunch. Drilled to 29.5' from 13:05 to 13:20. Tripped out of hole. *Began setting 13 3/8" surface casing to 29.5*' *at 13:45.* Rigged up cement pump, mixed cement, and pumped in hole by 15:00. *Used 29 bags of cement and 150 gallons of water.* Cleaned pump and equipment and left site at 15:20.

4-28-04 Arrived on site at 07:00. Held safety meeting. Began rigging up with 11" bit at 07:15 and began drilling from 29' at 07:50 . Compressor broke down at 08:00 after drilling about 3'. New compressor arrived on site at 10:00. Began drilling at 10:10. *Air pressure hose broke and was replaced.* Drilled to 36' at 10:45. Rigged up 11" reamers and diverter from 10:45 to 11:30. Waiting on Wagner to check on rented air compressor. Broke for lunch. Wagner checked compressors, departed 13:30. Finished rigging diverter by 13:42. *Compressors on line and working, air discharge fixed into rolloff.* Started drilling with air. *Reached 120*' *at 16:08, stopped to repair kelley drive bushing. Resumed drilling at 16:42.* Reached 183' at 17:58. Tripped out of hole and pumped diesel. Shut down and left site at 18:30.

4-29-04 Arrived on site at 07:00. Held safety meeting. Removed cuttings from around diverter and installed plywood barriers. Tripped into hole from 08:30 to 08:46 to 178', *indicating some fill. Ran electric probe inside drillpipe to 175*'*; no water detected. Circulated hole with air to remove cuttings; no water returned, and cuttings were dry.* Began drilling with air and slight amount of mist with Quik-Foam® at 183'. Drilled to 373' by 13:54. Hauled water. Drilled to 460' at 17:30. Circulated hole until 17:38; tripped out of hole by 18:00.

4-30-04 Arrived on site at 07:00. Held safety meeting. Filled compressors with diesel. Tripped into hole and checked for water with Solinst run inside drill pipe to 433'; no water detected. Circulated hole with air; no water blown from bottom. Began drilling with air and mist from 460' at 08:20. *Frac tank*

arrives at 09:20; Don Gilbert inspects frac tank and departs site at 09:43. Reached 512' *(coring point)* at 11:37. Circulated hole until 11:45. Tripped out of hole by 12:30. *Noted that piece of kelly bushing drive plate was missing and suspected to have fallen in hole. Tripped back into hole to determine if plate was hung up in hole. Brought magnet from Odessa; rigged up by 16:18. Tripped into hole with magnet and retrieved piece of drive plate. Shut down and left site at 17:25.*

5-3-04 Left Odessa at 06:40 and arrived on site at 08:40. Held safety meeting. Rigged up core barrel from 09:00 to 10:15. Tripped into hole with core barrel and began coring with air and mist from 512' at 11:17. Cored to 542' at 12:10; tripped out by 13:00. Broke for lunch. Laid core down; 100% recovery. Welded rig stand from 13:50 to 14:25. Tipped in hole with 11" bit. Reamed cored section from 15:30 to 16:50. Began drilling at 542' at 16:50. Drilled to 556' by 17:34. Tripped out of hole by 18:20. Used 2 gallons of Quik-Foam® during day. Secured site and left for evening at 18:25.

5-4-04 Arrived on site at 07:00. Held safety meeting. Tripped into hole to begin drilling. *Ran electric probe into hole through drilling pipe to 542'; did not detect water.* Began drilling from 556' at 07:52; reached 598' at 10:30. Tripped out of hole with 11" bit, and broke for lunch. Tripped into hole with core barrel and began coring from 598' at 13:05. Reached 627' at 14:12 and tripped out with core barrel. Laid down core (100% recovery) and reassembled core barrel. Hung core barrel in hole. Used 4 gallons of Quik-Foam® and one truck load of water during drilling for the day. Brought in one truck load of water. Left site at 16:30.

5-5-04 Arrived on site at 07:00. Held safety meeting. No water detected in hole. Tripped core barrel into the hole and circulated 5' of fill from hole. Began coring from 627' at 08:30. Reached 657' at 09:25. Circulated hole for 5 minutes. Tripped out with core barrel. Laid down core at 10:25; recovered 30'. Tripped back into hole by 11:50 and began coring from 657'. Reached 687' at 12:15. Circulated hole for 10 minutes. Tripped out of hole from 12:25 to 13:20. Laid core down and broke for lunch at 14:45. Broke down core barrel and loaded it on trailer. Prepared 11" bit and reamers. Placed 5 sacks of HolePlug® in hole from 687' to 674'. Used 3 gallons of Quik-Foam® during drilling. Shut down and left site at 16:15.

5-6-04 Arrived on site at 07:00. Held safety meeting. *Water level at 330*'. Tripped into hole with 11" bit to ream core section. Blew water from hole every 60'. Began reaming from 598' at 09:00. Hydraulic hose on rig went bad at 10:35. Went to Carlsbad for replacement. Resumed drilling at 12:15. Reached 671' at 13:55. Circulated for 15 minutes. Tripped out from 14:10 to 15:20. Used 2 gallons of Quik-Foam® during reaming. Left site for Odessa.

5-10-04 Left Odessa at 05:00 and arrived on site at 07:00. Held safety meeting. Ran sand line into hole and tagged bottom at 670' at 07:40. Removed diverter. Ran tremmie pipe into hole from 08:12 to 09:30. Ran 5" fiberglass reinforced plastic casing in hole from 09:30 to 11:00. Blank with bottom cap from 668' to 660'; perforated (0.020 inch) from 660' to 633.72'; blank from 633.72' to 2' above ground level. Placed 2800 pounds of 8/16 Brady sand from 668' to 625'. Placed 4 bags of HolePlug® from 625' to 620'. Waited on cement from 12:10 to 15:00. State Engineer representative arrived on site at 13:50. LaFarge cement trucks arrived 15:00. Cemented well from 620' to surface with 295 sacks of cement from 15:00 to 16:00. Pulled tremmie pipe from hole by 17:30. Cleaned equipment and left site.

5-11-04 *Arrived on site at 08:00. Held safety meeting. Loaded truck with fresh water. Pumped portable pits out. Set up to use drilling rig to jet screened interval. First return of water to surface at 11:00; water tan and slightly silty but cleared up rapidly. Water turned milky with some soapy bubbles at 11:06. Completed first pass by 11:25, with water muddy. Made second pass from 11:30 to 11:45, creating muddy water again. Circulated bottom of hole for several minutes. Sent truck for another load (90 bbls) of fresh water. Began another jetting at 12:30, with water light brown and silty. Water fairly clear by 12:40. Flushed bottom of well again at 12:50, with water still muddy. Started another pass at 13:00; water tan and silty. Cleared up rapidly and stayed clear to screen bottom. Flushed bottom of well again at 13:10; still fairly silty below screen base. Finished second truck full (180 bbls total) at 13:15. Began pipe removal and clean up. Pipe out of drillhole and laid down by 14:15. Left site.*

5-19-04 *Pumping of well began at 08:30 at 12 gpm; water tan, silty. Flow rate is 12 gpm at 08:45. Began backwash #1 at 09:00. Pumping at 12 gpm at 09:15, did another backwash. Backwashed again at 09:30; flow rate 12 gpm when started again. Pumping 12 gpm at 09:45. Pump off at 10:00; backwashed again. Pump back on at 10:05, pumping 12 gpm with wide open valve. Pumping at 12.5 gpm at 10:15; water cleared up nicely. Flow rate 10 gpm at 10:25. Flow rate dropped to 5.2 gpm at 10:40; water dirty, water level probably dropped greatly. Pump off at 10:42; backwashed. Pump on at 10:47 at 10 gpm; water very dirty brown. Flow rate 5 gpm at 11:10; water cleaned up well. Flow rate 5-6 gpm at 11:35; water silty. Pump off at 12:05, water was clear; backwashed again. Pump back on at 12:16; water silty, flow rate 8 gpm. Flow rate 5-6 gpm at 12:45; water clearer and lightly colored. Flow rate 5 gpm at 13:20; water clear. Flow 5-6 gpm and steady at 13:00; water very clear. Stopped pump at 15:30. Allow well to recover overnight.*

5-20-04 *Started pump at 08:15, valve wide open. Flow rate at 08:20 is 12 gpm; water is very dirty. Water cleaned up and clear at 08:27. Flow down to 8 gpm at 08:31; water very clear and clear. Flow rate 9 gpm and steady at 08:55. Stopped pum at 09:00; surged, backwashed well. Pumping at 09:09, water silted up a little; flow 9 gpm, clear. Turned pump off at 10:00; backwashed. Pump back on at 10:30; flow rate is 9 gpm. Water is light and silty. Density 1.006 g/cc at 24.6 degrees C. Flow is 8 gpm at 10:50; water is clear and clean. Flow rate 5.5 gpm, has dropped off at 11:20. Flow rate is 5.5 gpm at 12:10; density is 1.006 g/cc at 25.2 degrees C. Flow is 5 gpm at 13:00; density is 1.006 g/cc. Pump turned off at 14:00. Total of 3600 gallons pumped.*

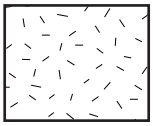
Appendix C
Geologic Logs

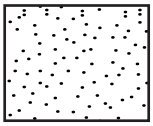
Note: The original field descriptions and graphic logs were prepared at differing scales, and the graphic logs for publication were generally produced at 10 or 20 vertical ft per inch, as indicated in the header for the log.

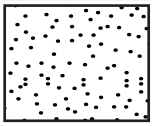
The field descriptions were related to depth based on drilling information and core recovery as best determined in the field. Core and sample footages are marked accordingly and can vary somewhat from depths determined for stratigraphic units based on geophysical logs (see Table 2-1 of text). Core depth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

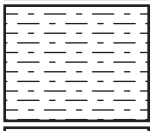
Explanation of Symbols Used in Lithologic Logs (Appendix C)

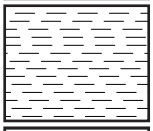
Lithology

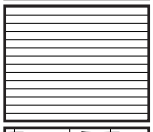

Construction fill

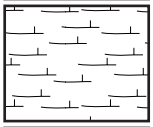

Fine sand or sandstone

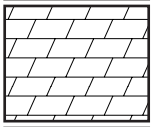

Medium or coarse sand or sandstone

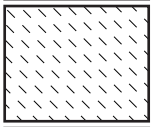

Siltstone

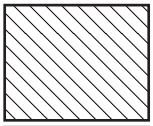

Claystone

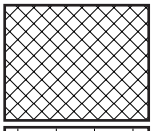

Organic-rich, claystone

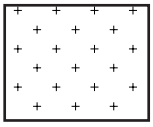

Carbonate (pedogenic calcrete)


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

Fractures, filled or unfilled

Erosional boundary

Sharp lithologic contact


Gradational lithologic contacts

sl Slickensides

ns No cuttings sample

Symbols may be combined; not all symbols may be used

CORE LOG Sheet 1 of 7

Hole ID: SNL-5
Location: 2011' fsl, 369' fel (SE 1/4), section 6, T22S, R31E, Eddy County, NM

Drill Date: 4/27/04-5/5/04
Drill Crew: WTWWS; Ronnie Keith, Driller
Drill Method: Rotary
Hole Diameter: 18" to 29.5'; 11" to TD
Hole Depth: 687.3'
Hole Orient: vertical
Drill Make/Model: Gardner-Denver 1500
Barrel Specs: 6" o.d.; 4" core
Drill Fluid: air with mist
Core Preserv: core boxes

Logged by: Dennis W. Powers, Ph.D.
Date: 4/27/04- 4/28/04
Scale: 1" = 10'; variable

UTM Zone 13 (NAD27)	Northing	Easting	Reference Point Elevation
Survey Coordinate: (m)	3587284.66	611969.97	3380 ft amsl (benchmark 3379.45 ft amsl)

Comments: This drillhole was permitted by the State Engineer (New Mexico) as C-3002.

Run Number	Depth (feet)	% Recovered	RQD	Profile (Rock Type)	Description	Remarks
	0					Drilling with air in portable pit
N/A		N/A	N/A		Drilled 1'; set diverter for cuttings and air. 0-1': construction fill 1-4': Sand, pinkish gray (7.5YR6/2; damp), very calcareous, moist from 2-4'. 4-7': Mescalero caliche. Sandstone, white (10YR8/1); fine to medium sand, subangular to subround, very calcareous; to sandy limestone. 7-36': Gatuña Formation. Sandstone, pink (5YR7/3) to yellowish red (5YR5/6), very calcareous; hard drilling 11-12'; few grayish-green chert pebbles; darker (5YR5/6) with depth as carbonate from Mescalero decreases; rare MnO_2 spots.	4/27/04 begin @ 1' @ 0929 MDT with 18" bit 4' @ 0935 MDT 5' @ 0940 MDT
		C-1 3'				
		C-2 5'				
		C-3 7'				
	10	C-4 10'				10' @ 0953 MDT stop 1009 MDT for work on compressors; begin 1015 MDT with mist and small amount of Quik-Foam 15' @ 1034 MDT lunch break 29.5' @ 1215 MDT; set 13.375" surface conductor casing & cemented end 4/27/04
		C-5 15'				
	20	C-6 20'				
	30	C-7 29.5'				Begin 4/28/04 @ 29.5', 0907 MDT 36' @ 0928 MDT; cuttings fine, took grab sample Compressor problems; begin 1242 from 36'
		C-8 36			Base of Gatuña Formation 36' Top of Dewey Lake Formation	
	40	C-9 40'			36-400': Dewey Lake Formation; siltstone, sandy, argillaceous; interbedded with sandstone, fine, silty; red (2.5YR5/6, damp to 2.5YR4/6, dry), with zones and spots of white (5YR6/1); noncalcareous to very calcareous to ~ 207'; gypsiferous from 207'.	40' @ 1247 MDT 45' @ 1256 MDT 50' @ 1302 MDT
		C-10 50'				
	50					

C-x indicates cuttings sample number

Hole ID: SNL-5 CORE LOG (cont. sheet) Sheet 2 of 7

Logged by: Dennis W. Powers, Ph.D. Date: 4/28/04-4/29/04

Run Number	Depth (ft)	% Recovered	RQD	Profile (Rock Type)	Note scale change Description	Remarks
N/A	50	N/A	N/A		36-400': Dewey Lake Formation; siltstone, sandy, argillaceous; interbedded with sandstone, fine, silty; red (2.5YR5/6, damp to 2.5YR4/6, dry), with zones and spots of white (5YR6/1); noncalcareous to very calcareous to ~ 207'; gypsiferous from 207'.	55' @ 1311 MDT
		C-11 60'				60' @ 1317 MDT
						65' @ 1325 MDT
	70	C-12 70'			60': siltstone and sandstone, similar to 40'; includes hard drilling zones (hz) every 1-2'; very calcareous; sand grains very fine to fine, subangular to subround, <1% opaques.	68' @ 1327 MDT; add jt, begin 1347
		C-13 80'			70': siltstone, as above, gray reduction spots.	70' @ 1348 MDT 75' @ 1357 MDT 80' @ 1406 MDT 85' @ 1409 MDT
	90	C-14 90'			80': similar to 60'	90' @ 1412 MDT
					90': as above	96' @ 1417 MDT; add jt, begin 1436
		C-15 100'			100': as above	100' @ 1439 MDT 105' @ 1444 MDT 110' @ 1451 MDT
	110	C-16 110'			110': as above	115' @ 1458 MDT
		C-17 120'			120': as above, more siltstone than sandstone	120' @ 1508 MDT
					130': as above, siltstone and sandstone about equal	124' @ 1513 MDT; add jt, begin 1542
	130	C-18 130'				125' @ 1543 MDT 130' @ 1546 MDT 135' @ 1551 MDT
		C-19 140'			140': as above	140' @ 1556 MDT
					150': as above, includes some gray sandstone	145' @ 1602 MDT
	150	C-20 150'				150' @ 1607 MDT 152' @ 1609 MDT; add jt, begin 1626
		C-21 160'			160': as above; little gray sandstone	155' @ 1629 MDT 160' @ 1633 MDT 165' @ 1638 MDT 170' @ 1644 MST
	170	C-22 170'			170': as above	175' @ 1649 MDT 180' @ 1654 MDT 183 @ 1659 MDT; end drilling 4/28/04; begin 4/29/04; no water in hole to 175'; begin 0747 MDT with QuickFoam and some fresh water
		C-23 180'			190': as above, more sandstone	185' @ 0748 MDT 190' @ 0752 MDT 195' @ 0755 MDT
	190	C-24 190'			200': as above, more siltstone	200' @ 0759 MDT 205' @ 0804 MDT
		C-25 200'			207': as above, gypsum in cutting 210': similar to 190', gypsum is white, fibrous, tabular chips indicating fracture or bedding plane filling, to ~0.25" thick; non-calcareous.	210' @ 0813 MDT
		C-26 208'				
	210	C-27 210'				

Hole ID: SNL-5 CORE LOG (cont. sheet) Sheet 3 of 7

Logged by: Dennis W. Powers, Ph.D. Date: 4/29/04

Run Number	Depth (ft)	% Recovered	RQD	Profile (Rock Type)	Description	Remarks
N/A	210	N/A	N/A		36-400': Dewey Lake Formation; siltstone, sandy, argillaceous; interbedded with sandstone, fine, silty; red (2.5YR5/6, damp to 2.5YR4/6, dry), with zones and spots of white (5YR6/1); noncalcareous to very calcareous to ~ 207'; gypsiferous from 207'.	215' @ 0820 MDT; add jt, begin 0841
		C-28 220'				220' @ 0848 MDT
						225' @ 0856 MDT
	230	C-29 230'			220': as above; less gypsum, less green sandstone	230' @ 0902 MDT
					230': as above	235' @ 0910 MDT
		C-30 240'			240': as above	240' @ 0921 MDT 245' @ 0930 MDT 247' @ 0932 MDT; add jt, begin 0953
	250	C-31 250'			250': as above	250' @ 0957 MDT
					260': as above	255' @ 1003 MDT
		C-32 260'				260' @ 1008 MDT
						265' @ 1013 MDT
	270	C-33 270'			270': as above, minimal gypsum; gypsum increase @ ~275'	270' @ 1016 MDT
						275' @ 1021 MDT
		C-34 280'			280'-320': as above	278' @ 1025 MDT; add jt, begin 1045 280' @ 1049 MDT 285' @ 1054 MDT
	290	C-35 290'				290' @ 1058 MDT
						295' @ 1103 MDT
		C-36 300'				300' @ 1105 MDT 305' @ 1108 MDT
	310	C-37 310'				310' @ 1111 MDT; add jt; begin 1147
						315' @ 1150 MDT 320' @ 1153 MDT
		C-38 320'				325' @ 1157 MDT 330' @ 1201 MDT
					330': as above, more gray siltstone and sandstone	335' @ 1205 MDT 340' @ 1208 MDT
	330	C-39 330'				341.5' @ 1210 MDT; add jt, begin 1226
						345' @ 1229 MDT 350' @ 1232 MDT
		C-40 340'				355' @ 1234 MDT 360' @ 1237 MDT
					350': as above, less gypsum	
	350	C-41 350'				365' @ 1242 MDT
						370' @ 1245 MDT
		C-42 360'				
		C-43 370'				
	370					

Hole ID: SNL-5 CORE LOG (cont. sheet) Sheet 4 of 7

Logged by: Dennis W. Powers, Ph.D. Date: 4/29/04

Run Number	Depth (ft)	% Recovered	RQD	Profile (Rock Type)	Description	Remarks
	370				Note scale change	
N/A		N/A	N/A		36-400': Dewey Lake Formation; siltstone, sandy, argillaceous; interbedded with sandstone, fine, silty; red (2.5YR5/6, damp to 2.5YR4/6, dry), with zones and spots of white (5YR6/1); noncalcareous to very calcareous to ~ 207'; gypsiferous from 207'.	373' @ 1247 MDT; add jt, begin 1343 375' @ 1345 MDT
	380	C-44 380'			360': as above, less gypsum	380' @ 1350 MDT
					370'-430': as above	385' @ 1353 MDT
	390	C-45 390'				390' @ 1357 MDT
						395' @ 1400 MDT
	400	C-46 400'				400' @ 1403 MDT
						405' @ 1406 MDT add jt
	410	C-47 410'				410' @ 1438 MDT
						415' @ 1449 MDT
	420	C-48 420'				420' @ 1458 MDT
						425' @ 1505 MDT
	430	C-49 430'				430' @ 1517 MDT
						435' @ 1526 MDT 436' @ 1527 MDT, add jt, begin 1541
	440	C-50 440'				440' @ 1547 MDT
					440': as above, slightly more gypsum	445' @ 1557 MDT
	450	C-51 450'				450' @ 1603 MST

Hole ID: SNL-5 CORE LOG (cont. sheet) Sheet 5 of 7

Logged by: Dennis W. Powers, Ph.D. Date: 4/29/04-4/30/04; 5/3/04

Run Number	Depth (ft)	% Recovered	RQD	Profile (Rock Type)	Description	Remarks
N/A	450	N/A	N/A		Base of Dewey Lake Formation 455’ Top of Rustler Formation (Forty-niner Member)	455’ @ 1610 MDT; 456’ @ 1625 MDT
		C-52 456’				460’ @ 1630 MDT; end drilling 4/29/04 begin 4/30/04 @ 460’ @ 0719 MDT
	460	C-53 460’			460’: Anhydrite and gypsum, gray (5YR6/1; wet); fine crystalline	
					A-5	470’ @ 0806 MDT 485’ @ 0909 MDT
	470	C-54 470’				490’ @ 0913 MDT 495’ @ 0918 MDT 500’ @ 0928 MDT
						504’ @ 0942 MDT; add jt; stop for junk in hole
	480	C-55 480’				
		C-56 485’			484’: easier drilling. 484-492’: Siltstone and sandstone; argillaceous, reddish brown (2.5YR5/3; wet); non-calcareous	
	490	C-57 490’			M-4/H-4	
		C-58 495’			492-497’: Siltstone, argillaceous, light brownish gray (10YR6/2; wet); non-calcareous	
		C-60 497’				
	500	C-61 500’			497-514.3’: Anhydrite and gypsum, gray, fine to coarsely crystalline; includes thin beds and laminae of dolomite in basal cored portion.	505’ @ 1015 MDT
		C-62 505’				510’ @ 1030 MDT
					A-4	512’ @ 1036 MDT; end drilling 4/30/04 Begin coring from 512’ on 5/3/04
	510	C-63 510’ C-64 512’				
		512’			Base of Forty-niner Member 514.3’ Top of Magenta Dolomite Member	
1	520	Cut 30’; recovered 30’	0.8’ in segments < 4" long (RQD = 97.33) *porous zone*		514.3-538.7’: Dolomite, gray; gypsiferous, with some zones of gypsum; laminar to wavy bedding 1/16-1/4" thick, with low-angle cross-cutting beds increasing upwards; algal features 537.5-538.5’; organic-rich 516-519.2’; most porous zone from 516-520.5’. Nodular gypsum with dolomite from 520.6-520.8’; nodules from 521.6-522.5’, 528-529’. Gypsum-filled separations from 533.7-536’.	Cored from 512’ with air and foam; reamed from 512-542’ after coring beginning @ 1433 MDT
	530					

Hole ID: SNL-5 CORE LOG (cont. sheet) Sheet 6 of 7

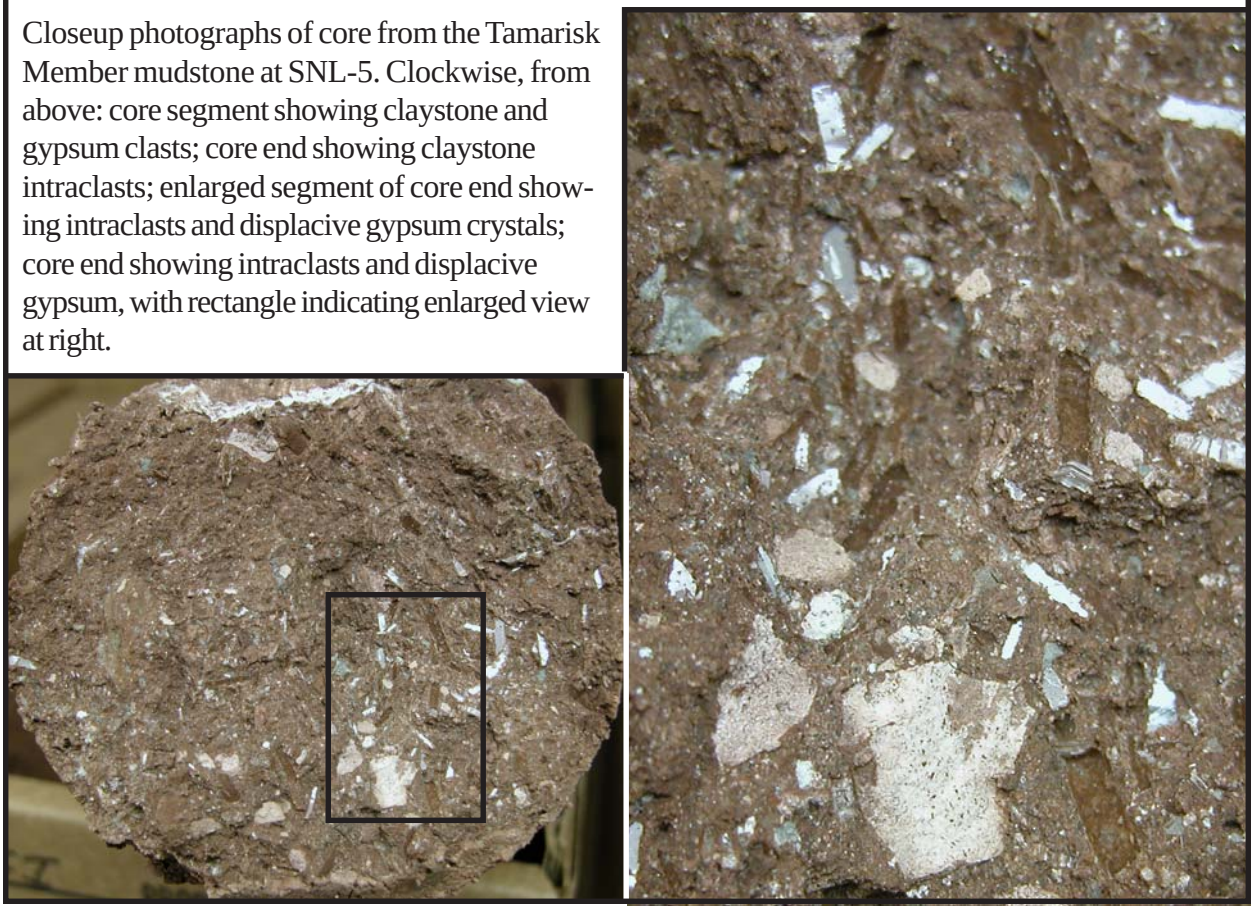
Logged by: Dennis W. Powers, Ph.D. Date: 5/3/04-5/4/04

Run Number	Depth (ft)	% Recovered	RQD	Profile (Rock Type)	Description	Remarks
1	530				Base of Magenta Dolomite Member 538.7' Top of Tamarisk Member	
	540					
		542'				
N/A		N/A	N/A		Gypsum and anhydrite, dark gray, fine crystalline; poorly bedded, some possible nodules in upper part.	
		C-65 545'				545' @ 1558 MDT
	550	C-66 550'				550' @ 1617 MDT
						556' @ 1634 MDT; end 5/3/04
						No water to 542' at 0647 MDT 5/4/04; begin drilling from 556' at 0652 MDT.
	560	C-67 560'				560' @ 0712 MDT
						add jt @ 567'
	570	C-68 570'				570' @ 0819 MDT
					A-3	
	580	C-69 580'				580' @ 0852 MDT
	590	C-70 590'				590' @ 0913 MDT
		C-71 598'				
		598'				598' @ 0930 MDT
2	600	Cut 29'; recovered 29.3'	0.5 ft in segments < 4" long (RQD = 97.95)		Anhydrite, gray, fine grained, and gypsum, clear, coarse; bedded to laminar, with wavy to inclined beds (dips generally <15^{o}) at 605', becoming more inclined and brecciated at 608-611.2'. Large blocks near base; includes siltstone clast, gray claystone.	Begin coring
	610					

Hole ID: SNL-1 CORE LOG (cont. sheet) Sheet 7 of 7

Logged by: Dennis W. Powers, Ph.D. Date: 5/4/04-5/5/04

Run Number	Depth (ft)	% Recovered	RQD	Profile (Rock Type)	Description	Remarks
	610				no core recovered	
2				M-3/H-3	611.2-618.3': Siltstone and claystone, reddish brown (2.5YR4/4) with some gray reduction zones; large angular gypsum clasts (~2") in upper 1.3'; includes smaller intraclasts at 614-615.8'; small fractures filled with gypsum; base gradational over ~2".	
	620			A-2	618.3-634.8': Gypsum, dark gray, coarse, with anhydrite, fine; inclined bedding (~20-30^{o}) near top; some bedding deeper, horizontal; gray siltstone and clay, with gypsum-filled fractures 624.5-624.8'; reddish zone at 628-629'.	end coring 5/4/04 @ 627.3'; begin 5/5/04, no water detected in drillhole
		627.3'			Base of Tamarisk Member	
	630				634.8' Top of Culebra Dolomite Member	
3		Cut 30'; recovered 30'	5.6' in segments < 4" long (RQD = 80.67)		Dolomite, light gray (5Y7/2), with gypsum; thin bedded to laminar; vugs 1/16-3" along horizontal zones; some vertical to near-vertical fractures; more gypsum below 650'; short subvertical fractures and slight brecciation below 653'; irregular upper surface. 634.8': Organic-rich, laminar. 635-639.3': Fine grained, silty, large vugs and high-angle fracture. 639.3-641': bedded and laminar, very porous zone with abundant small (<1/8") vugs, some gypsum fill, some silt fill. 641-645.6': more silty, less porous, possibly more silt filling than above; gypsum on fracture surfaces. 645.6-653': abundant small pores (~1/16-1/4", some to 1"), elongated along horizontal plane; gypsum on high-angle fractures below 650'; thin (~1/4") laminar zones spaced 2-6". 653-657': as above, fewer small pores, some brecciation. 657-657.9': laminae, thin beds, slight deformation; contact grades over 1".	
	640					
	650					
		657.3'			Base of Culebra Dolomite Member	
	660				657.9' Top of Los Medaños Member	
4		Cut 30'; recovered 30'	2.4' in segments < 4" long (RQD = 92)	M-2/H-2	657.9-659': Claystone, light brownish gray (2.5Y6/2), some bedding and laminae. 659-661.2': Siltstone, weak red (10R4/2), zones of light brownish gray (2.5Y6/2). Some gypsum clasts; gypsum fracture fillings. 661.2-665.3': Siltstone, sandy, with large subangular clasts of gypsum and anhydrite from 663-665'. Diagonal fractures and bedding plane separations have fibrous gypsum. Some gray mottling.	
	670			A-1	665.3-674.8':Anhydrite, gray, fine grained; thin beds and fine laminae; reddish color 672.5-673.2'; reddish, with coarse gypsum 665.3-666.7'.	
					674.8-679': Siltstone, sandy, reddish brown (2.5YR4/4) with possible clasts of siltstone in lower part. Gradational upper contact. 679-679.9': Siltstone, reddish brown, overlain by gray laminated anhydrite; siltstone in anhydrite increases upward.	
	680			M-1/H-1	679.9-683': Halite, clear to brown or orange; coarse; some bedding; thin gypsum films on some crystals; amalgamated gypsum @ 681.3'. 683': Anhydrite, gray, and pinkish gypsum, with siltstone and halite 683-687.3': Siltstone, sandy, reddish brown (2.5YR4/4); interbedded with, and cemented by, fine to medium halite; some corroded halite.	
					Total depth: 687.3'.	end coring 5/5/04 @ total depth: 687.3'
	690					



Closeup photographs of core from the Tamarisk Member mudstone at SNL-5. Clockwise, from above: core segment showing claystone and gypsum clasts; core end showing claystone intraclasts; enlarged segment of core end showing intraclasts and displacive gypsum crystals; core end showing intraclasts and displacive gypsum, with rectangle indicating enlarged view at right.

Appendix D
Geophysical Logs

Geophysical logging of SNL-5 was conducted by Geophysical Logging Services, 6250 Michele Lane, Prescott, AZ 86305, on May 7, 2004. The operator was Raymond Federwisch. 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 Geophysical Logging Services using WellCAD vs 3.2,
2) WellCAD Reader to open the electronic logs, and
3) Electronic data files in both .txt and .las formats.

On May 7, 2004, the following geophysical logs were obtained:

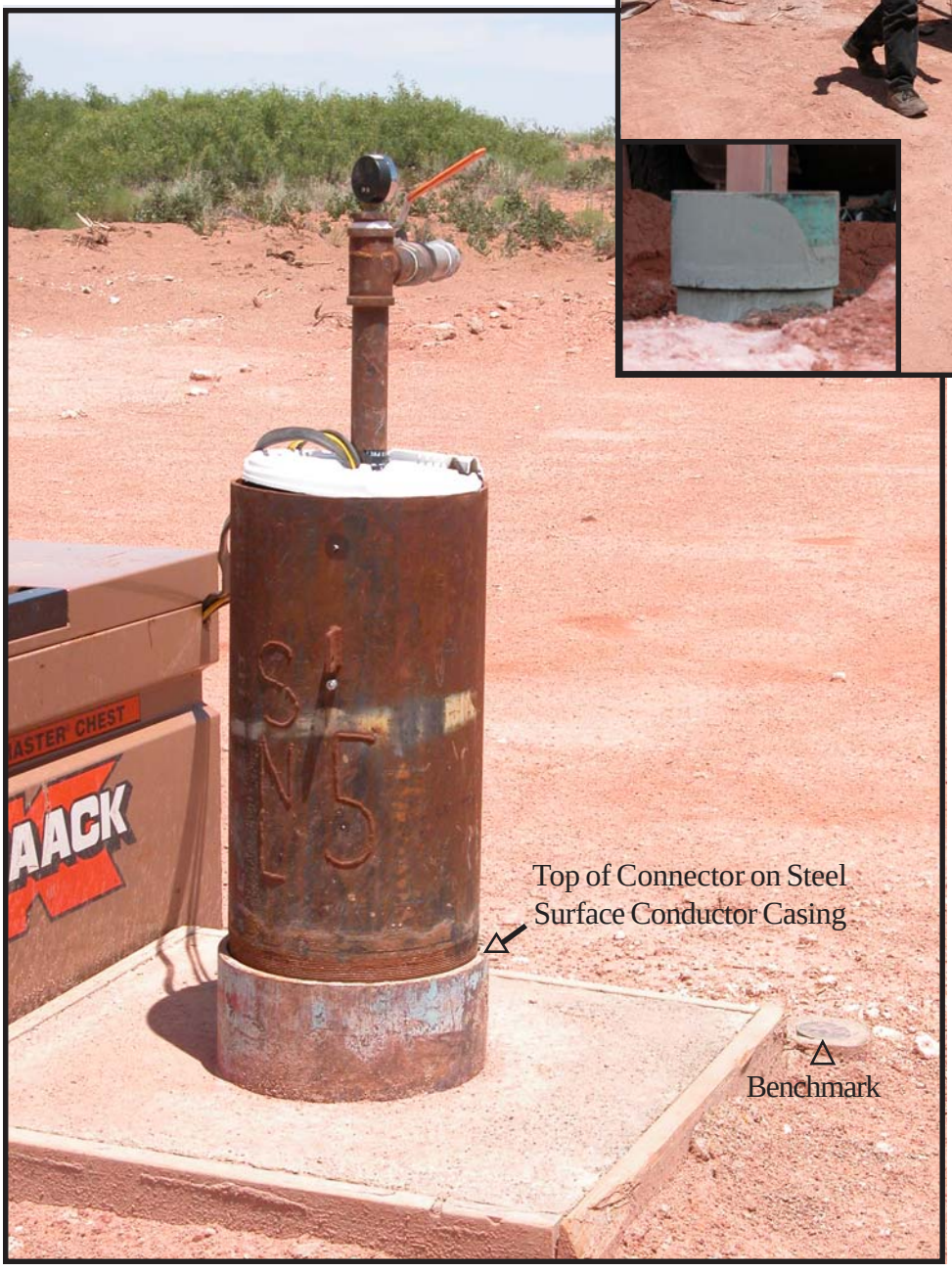
- Caliper
- Natural gamma
- Neutron
- Density
- Formation resistivity (including induction log)
- Fluid resistivity
- Fluid temperature
- Formation conductivity
- Spontaneous potential (SP)

SNL-5 had been cored and drilled to about 687.3 ft at the time of logging. A conductor casing had been placed to a depth of 30 ft bgl. The fluid level had risen in the drillhole, from inflow, to approximately 330 ft below the surface at the time of logging. SNL-5 was drilled with air and foam, with little water introduced during drilling.

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 is the top of the connector on the surface conductor casing (see photo, next page). This point was assigned an elevation of 3380 ft amsl on the logs, based on the topographic map for the drillhole location. A benchmark placed near the drillhole after completion has an elevation of 3379.45 ft amsl (see Fig. 1-5 and Table 1-1 in the main text). The connector is several inches above the pad surface (see photos next page), and the rounded elevation of 3380 ft amsl for the reference point is appropriate for the measurements.

Geophysical Logging Services logging vehicle (right) set up and logging SNL-5 on May 7, 2004. The inset photo shows the top of the connector on the surface casing during drilling of SNL-5. The top of the connector is the reference point (0 ft depth) for logging and setting casing. The photo below taken June 21, 2004, shows the completed well configuration and the top of the connector. The well is configured for continuous water level monitoring.



Appendix E
Permitting and Completion Information

A case file for SNL-5 (C-3002) 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-3002.

Well-drilling wastes for SNL-5 were disposed of at the Lea Land, Inc. landfill north of WIPP; pumped water produced during well development was disposed of at the H-19 disposal site operated by WIPP, and WRES maintains records of necessary analyses.

Dennis W. Powers, Ph. D.
Consulting Geologist

May 11, 2004

Ron Richardson
Field Lead
WRES

Rick Beauheim
Hydrology Lead
Sandia National Laboratories

Re: Screen Interval for Culebra Dolomite Member in SNL-5

Our discussions regarding the Culebra Dolomite Member in SNL-5 indicate that the best interval to screen is from 660-633.7 ft below the top of the connector on the permanent conductor casing (reference point). This decision is based on geophysical logs completed on May 7, 2004 (see attached figure) and cores recovered during drilling.

These are factors considered in this decision for SNL-5:

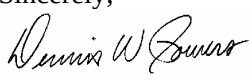
- The Culebra interval, based on the natural gamma geophysical log, is from 660–637 ft. This interval is 23 ft thick, about average around the WIPP site.
- The screened or slotted section of the casing joint is 26.3 ft long. This will provide a screened interval that will incorporate all of the Culebra.
- Core across the transition from Culebra to Los Medaños included light gray claystone that is moderately indurated. The base of the screen was placed at this contact to prevent squeezing of the claystone into the screen, although the claystone is not very plastic.
- The laminated claystone and mudstone (M-2/H-2) below the Culebra was cored. There is no salt in this section, and it does not need to be cemented.
- Cores through A-1 and into M-1/H-1 revealed that nearly pure salt underlies A-1 at a cored depth of 679.9 ft. Pellet bentonite was added to seal the hole up into the lower part of A-1. The cored interval above this was then reamed to 11” diameter to the upper part of A-1 at a depth of 672 ft, but the bentonite-filled section was not re-drilled.
- Geophysical logs and core above the Culebra indicate the anhydrite/gypsum unit (A-2) is relatively intact and separates the Culebra from the Tamarisk Member mudstone (M-3/H-3) by 17 ft. The base of M-3 is at 620 ft.

By placing the bottom of the screened interval at 660 ft, clays in the lower Culebra should be prevented from squeezing into the screens. The top of the screened interval at 633.7 ft should be isolated from M-3/H-3. The top of the sand pack should not be higher than about 625–627 ft, and bentonite to 622–620 ft will prevent circulation into M-3/H-3 through the annulus.

To provide sump space below the screened interval, 7–8 ft of blank casing with an end cap will be added below the screened interval. The hole should be separated geologically from the lower Los Medaños Member, and the sand pack will be started from 672 ft.

I believe this letter summarizes our discussions and presents the hydrological and geological justification for setting the screened interval and preparing SNL-5 for completion.

Sincerely,



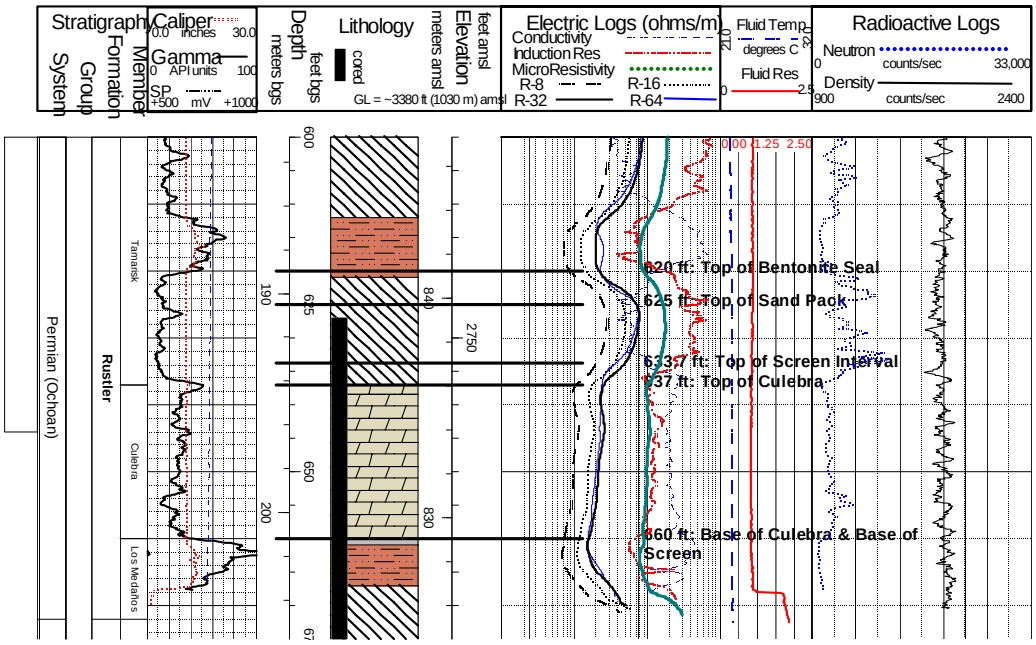
Dennis W. Powers

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

Dennis W. Powers, Ph. D.
Consulting Geologist

May 11, 2004

Partial Geophysical Log of SNL-5



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

Dennis W. Powers, Ph. D.
Consulting Geologist

May 4, 2004

Rey Carrasco
Geotechnical Engineering
Washington TRU Solutions
Carlsbad, NM 88220

Storage and Retention of Cores and Rock Samples from SNL-5

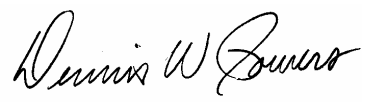
Background
Cores and cutting samples have been collected from drillhole SNL-5 in support of the drilling and testing program to investigate the hydrology of the Culebra Dolomite Member of the Rustler Formation as well as other units of hydrogeological significance to the program. These samples were collected under my supervision, and the chain-of-custody has been maintained by me or WRES personnel. SNL-5 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-5 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-5 are likely to be accessed in the next few months for further geologic studies to establish more details of stratigraphic, sedimentologic, and diagenetic conditions and events. These studies, if carried out, will be carried out under a formal plan, most likely developed under QA requirements of Sandia National Laboratories.

Core and Cuttings Retention Periods
It is recommended that cores obtained from SNL-5 be maintained indefinitely under normal storage conditions because of their relevance to hydrology and monitoring programs. The cores can be accessed for observations, and they can be removed for further laboratory study, including possible destruction, under a plan with appropriate management and QA approval.

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

Supplemental Information
Descriptive core logs and digital photographs of cores with a photograph log will be provided to you on CD-ROM format in accessible formats when the content has been reviewed for the basic data report for SNL-5.



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

Roswell Office
1900 WEST SECOND STREET
ROSWELL, NM 88201

STATE OF NEW MEXICO
OFFICE OF THE STATE ENGINEER

Trn Nbr: 284766
File Nbr: C 03002

Oct. 1, 2003

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

Greetings:

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

In accordance with General Condition C, a well record shall be filed in this office ten (10) days after completion of drilling. The well record is proof of completion of the 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 09/30/04, unless the well has been drilled and the well log filed in this office.

Sincerely,

Mike Stapleton
(505)622-6467

Enclosure

cc: Santa Fe Office

explore

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 03002 must be completed and the Well Log filed on or before 09/30/2004.

ACTION OF STATE ENGINEER

Notice of Intention Rcvd: Date Rcvd. Corrected:
Formal Application Rcvd: 09/18/2003 Pub. of Notice Ordered:
Date Returned - Correction: Affidavit of Pub. Filed:

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

Witness my hand and seal this 29 day of Sep A.D., 2003

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

By: _____
Art Mason

Trn Desc: C 03002 MONITORING WELL File Number: C 03002
Trn Number: 284766

page: 1

Addendum to "A Survey for the SNL-5 Water Well"

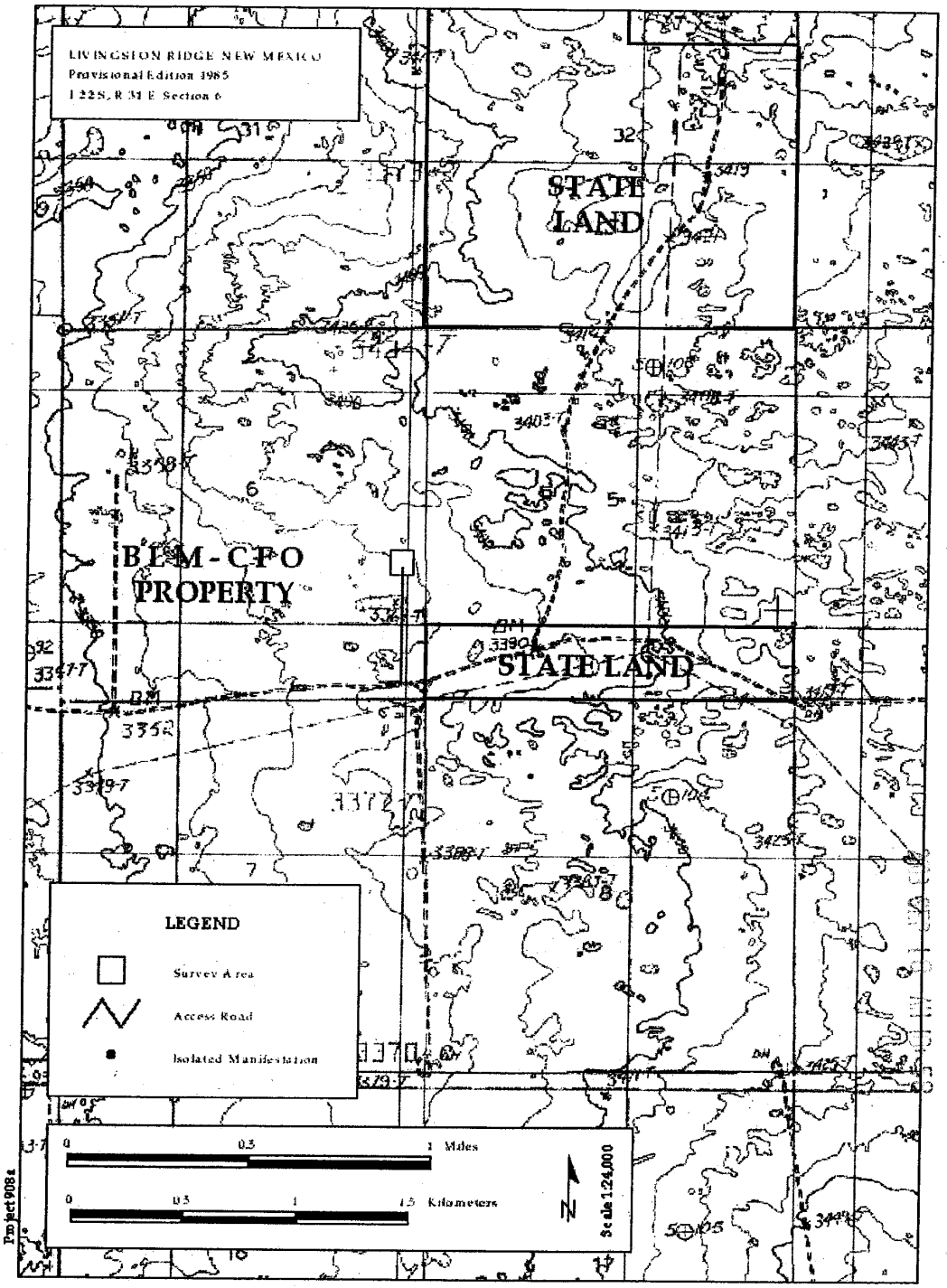


Figure 1. Project Area Map ***Mesa Field Services***

file://C:\TEMP\snl-5map.jpg 9/4/03

SW 5

Revised August 1967

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 09/18/03 File No. C-3002

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 Culebra Dolomite member of the Rustler formation (Artesian or shallow water aquifer), located in Carlsbad, (Name of underground basin)

3. The well is to be located in the SE, ¼ NE ¼ SE ¼, Section 6 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 Energy, Carlsbad Field Office - See Attached Plat of Survey

4. Description of well: name of driller West Texas Water Well Service,
   Outside Diameter of casing 5.5" fiberglass inches; Approximate depth to be drilled 800' bgs 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 This well is to be drilled as an exploration/monitoring well only. It will be drilled to an approximate total depth of 800' below ground surface in order to acquire access to the Culebra Dolomite member of the Rustler formation. Casing and cement inspections have been identified as hold points pending on site inspections by personnel from the New Mexico Office of the State Engineer. After the initial drilling, pump tests will be conducted to determine the production capacity of the Culebra. These will occur for approximately 96 hours @ 20 gallons per minute. After the completion of the initial pump test, this well will be used for routine monitoring purposes (e.g., water level measurements).

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, Permittee,

By: Harold Johnson

Subscribed and sworn to before me this 16 day of September, A.D., 20 03

My commission expires 5-4-2005 Yolanda R. Sandate
Notary Public
284766

Number of this permit_____

ACTION OF STATE ENGINEER

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

see attached conditions

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

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

Witness my hand and seal this 29th day of September, A.D., 20 03

~~Thomas C. Turney~~, State Engineer
John R. D'Antonio, Jr., P.E.

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 $25.00. Each of triplicate copies must be properly signed and attested.

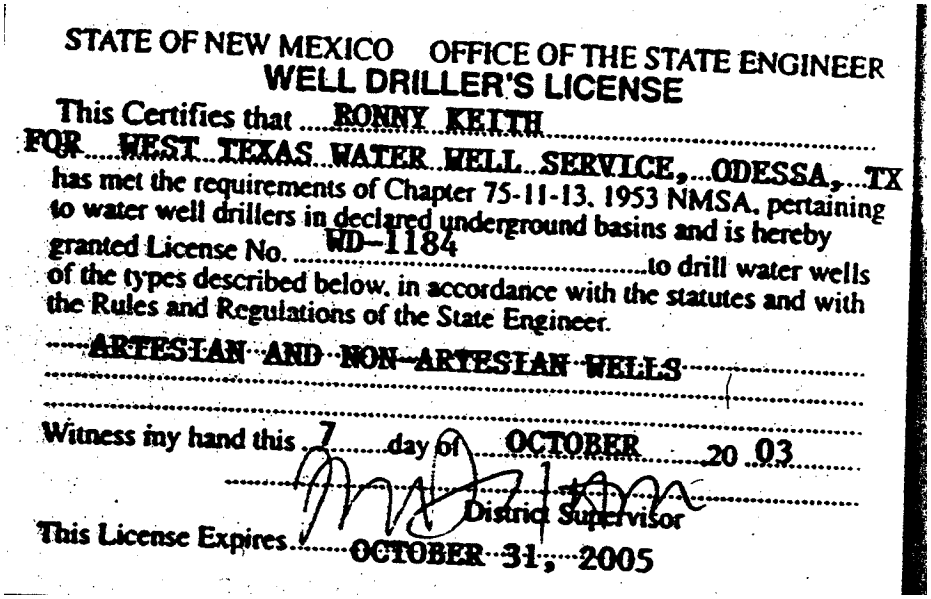
A separate application for permit must be filed for each well used.

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

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

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

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



STATE OF NEW MEXICO OFFICE OF THE STATE ENGINEER

WELL DRILLER'S LICENSE

This Certifies that RONNY KEITH

FOR WEST TEXAS WATER WELL SERVICE, ODESSA, TX

has met the requirements of Chapter 75-11-13, 1953 NMSA, pertaining to water well drillers in declared underground basins and is hereby granted License No. WD-1184 to drill water wells of the types described below, in accordance with the statutes and with the Rules and Regulations of the State Engineer.

ARTESIAN AND NON-ARTESIAN WELLS

Witness my hand this 7 day of OCTOBER 20 03

District Supervisor

This License Expires OCTOBER 31, 2005

Revised June 1972

STATE ENGINEER OFFICE

WELL RECORD

Section 1. GENERAL INFORMATION

(A) Owner of well WASHINGTON TRU SOLUTIONS Owner's Well No. SNL-5
Street or Post Office Address P.O. BOX 2078
City and State CARLSBAD, NEW MEXICO 88221

Well was drilled under Permit No. C 03002 and is located in the:

a. NE ¼ SE ¼ ¼ ¼ of Section 6 Township 22S Range 31E 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 _____ County.

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

(B) Drilling Contractor WEST TEXAS WATER WELL SERVICE License No. WD-1184

Address 3410 MANKINS ODESSA, TEXAS 79764

Drilling Began 04-27-04 Completed 05-10-04 Type tools AIR ROTARY Size of hole 11 in.

Elevation of land surface or _____ at well is 3380 ft. Total depth of well 668 ft.

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

Section 2. PRINCIPAL WATER-BEARING STRATA

Depth in Feet From	Depth in Feet To	Thickness in Feet	Description of Water-Bearing Formation	Estimated Yield (gallons per minute)
635	658	23	LIGHT BROWN DOLOMITE, RUSTLER FORMATION	

Section 3. RECORD OF CASING

Diameter (inches)	Pounds per foot	Threads per in.	Depth in Feet Top	Depth in Feet Bottom	Length (feet)	Type of Shoe	Perforations From	Perforations To
13-3/8	48	8	2' AGL	29.6	31.6			
5" FIBERGLASS	3.2	4	2' AGL	668	670	FIBERGLASS CAP ON BOTTOM	.020 SCREEN 633.72	660

Section 4. RECORD OF MUDDING AND CEMENTING

Depth in Feet From	Depth in Feet To	Hole Diameter	Sacks of Mud	Cubic Feet of Cement	Method of Placement
0	29.6	18" 13-3/8 CSG		29	TRIMMIE
687	674	6-3/4	HOLE PLUG 5		
29.6	668	11"		295	TRIMMIE

Section 5. PLUGGING RECORD

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

_____
State Engineer Representative

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

FOR USE OF STATE ENGINEER ONLY

Date Received

Quad _____ FWL _____ FSL _____

File No. _____ Use _____ Location No. _____

Section 6. LOG OF HOLE

Depth in Feet From	Depth in Feet To	Thickness in Feet	Color and Type of Material Encountered
0	4	4	CONSTRUCTION FILL & GRAY CALCAREOUS SAND
4	10	6	WHITE CALICHE & CALCAREOUS SAND (MESCALERO)
10	30	20	YELLOWISH RED CALCAREOUS SANDSTONE WITH CHERT PEBBLES (GATUNA FORMATION)
30	307	277	RED TO REDDISH BROWN CALCAREOUS SANDY SILTSTONE & SILTY CLAYSTONE (MIDDLE TO UPPER DEWEY LAKE FORMATION)
307	455	148	REDDISH BROWN GYPSIFEROUS SANDY SILTSTONE & SILTY CLAYSTONE (LOWER DEWEY LAKE FORMATION)
455	514	59	WHITE GYPSUM BEDS WITH INTERMEDIATE GRAY TO REDDISH BROWN CLAYSTONE (FORTY-NINER MEMBER OF RUSTLER FORMATION)
514	539	25	WHITE TO GRAYISH BROWN GYPSIFEROUS DOLOMITE (MAGENTA DOLOMITE MEMBER OF RUSTLER FORMATION)
539	635	96	WHITE GYPSUM BEDS WITH INTERMEDIATE GRAY TO REDDISH BROWN CLAYSTONE (TAMARISK MEMBER OF THE RUSTLER FORMATION)
635	658	23	LIGHT BROWN DOLOMITE (CULEBRA DOLOMITE MEMBER OF THE RUSTLER FORMATION)
658	665	7	DARK GRAY TO REDDISH BROWN GYPSIFEROUS CLAYSTONE (UPPER LOS MEDANOS MEMBER OF THE RUSTLER FORMATION)
665	675	10	WHITE ANHYDRITE & GYPSUM (UPPER LOS MEDANOS MEMBER OF THE RUSTLER FORMATION)
675	687	12	BROWN TO CLEAR HALITE & REDDISH BROWN HALITIC MUDSTONE (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 Reid
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.

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-110735
2805(080)bky

COPY

OCT 17 2003

RIGHT-OF-WAY RESERVATION

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 for 2 wellbores and road access for the expressed purpose of conducting groundwater investigations in support of the WIPP, over the following described real property situated in the County of Eddy, State of New Mexico to wit:

T. 21 S., R. 31 E., NMPM
Sec. 31: Lots 3, 4. (SNL-11, 1979 FSL, 331 FWL)
T. 22 S., R. 31 E., NMPM
Sec. 06: Lots 4, 5, E½SE¼. (SNL-5, 1980 FSL, 330 FEL)

Each well site location contains approximately 0.517 acres (approximately 150' X 150'), with 1.034 acres for 2 sites. The road to SNL-11 is 3875.03 feet length and the road to SNL-5 is 1666.26 length, both roads are 20 feet in width, for a total of 2.544 acres. Total acreage is 3.578.

Plats showing the right-of-way described above is attached hereto as Exhibit A and made a part hereof. Archaeological stipulations are attached for SNL-11.

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 October 3, 2003.

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, 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

UNIQUE #	DOE UFC	DATE REC'VD	ADDRESSEES
030305	5400.00	OCT 20 2003	H Johnson

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 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 according to Bureau of Land Management specifications. Attached are stipulations for general operations. Exhibit B.

D. The wells shall be properly plugged (See the attached Casing Program Plugging and Abandonment Requirements). Exhibit C.

6. This reservation shall be renewable and shall have a 30-year term, commencing on the date shown below.

Dated this 16th day of October, 2003.

for Leslie A. Theiss, Field Manager
Carlsbad Field Office, BLM

EXHIBIT NO. _____

CULTURAL RESOURCES STIPULATIONS
CARLSBAD FIELD OFFICE

PROJECT NAME: SNL-11 Water Well and Access Road

REPORT NUMBER: BLM 03-NM-080-723; MFS-909

SITE PROTECTION AND EMPLOYEE EDUCATION: All employees of the project shall be informed that cultural sites are to be avoided by all personnel, personal vehicles and company equipment. They shall also be notified that it is illegal to collect, damage or disturb cultural resources.

YES A. Monitoring is required.

YES 1. A copy of these stipulations shall be supplied to the archaeological monitor at least five (5) working days prior to the start of construction activities.

YES 2. No construction activities, including vegetation removal, may begin before the arrival of the archaeological monitor.

YES 3. The archaeological monitor will:

NO a. Ensure that the site protection barrier is located as indicated on the attached map.

YES b. No widening or blading of the road allowed within or near 100 feet of LA 125,899 (see attached map). However, if necessary, caliche may be laid on the surface of the **existing** road within LA 125,899 to even the road. This activity shall be monitored too.

NO c. Other:

YES d. Submit a report of the monitoring activities within thirty (30) days of completion of monitoring unless other arrangements are made with the BLM. These stipulations must be attached to the report.

YES B. The grantee must select one of the following alternatives:

NO 1. Controlled test excavations to determine if cultural resources are present;

YES 2. Reduction of the project size to avoid all significant cultural materials; No blading or widening the road within and near LA 125,899.

NO 3. Relocation of the project;

NO 4. Preparation and implementation of a data recovery plan for cultural sites(s)

NO C. SITE BARRIER/FENCING:

NO 1. A temporary site protection barrier(s) shall be erected prior to construction. The barrier(s) shall, at a minimum, consist of upright wooden survey lath spaced no more than ten (10) feet apart and marked with blue ribbon flagging or blue paint. There shall be no construction activities or vehicular traffic past the barrier(s). The barrier(s) shall remain in place through reclamation and reseeding.

NO 2. A permanent fence shall be erected prior to construction. There shall be no construction activities or vehicle traffic past the fence. An archaeologist shall monitor the construction of the fence.

NO 3. The barrier/fence shall be placed as indicated on the attached map.

YES D. CONSTRUCTION ZONES: There shall be a no construction zone within or near LA 125,899.

E. OTHER:

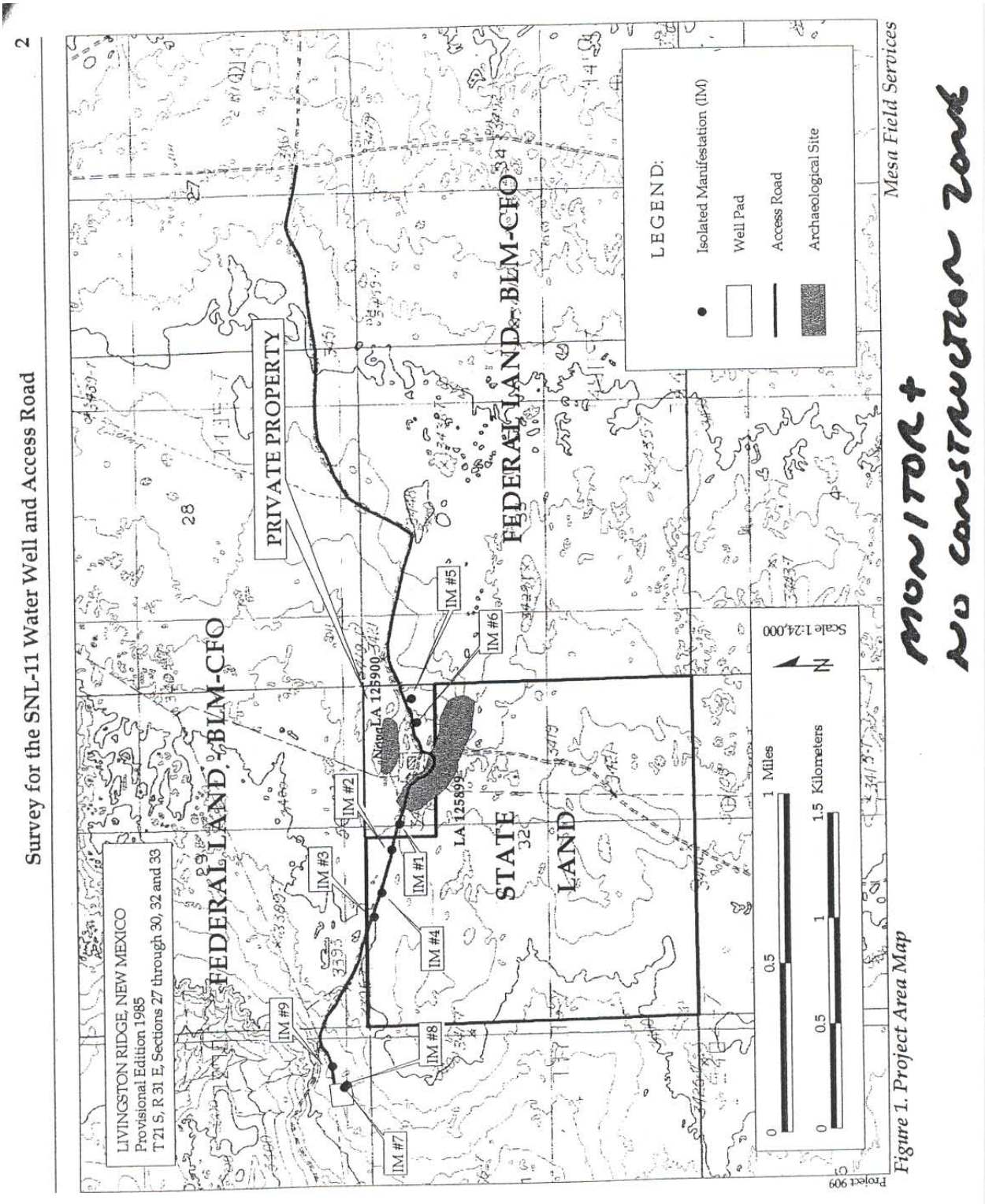
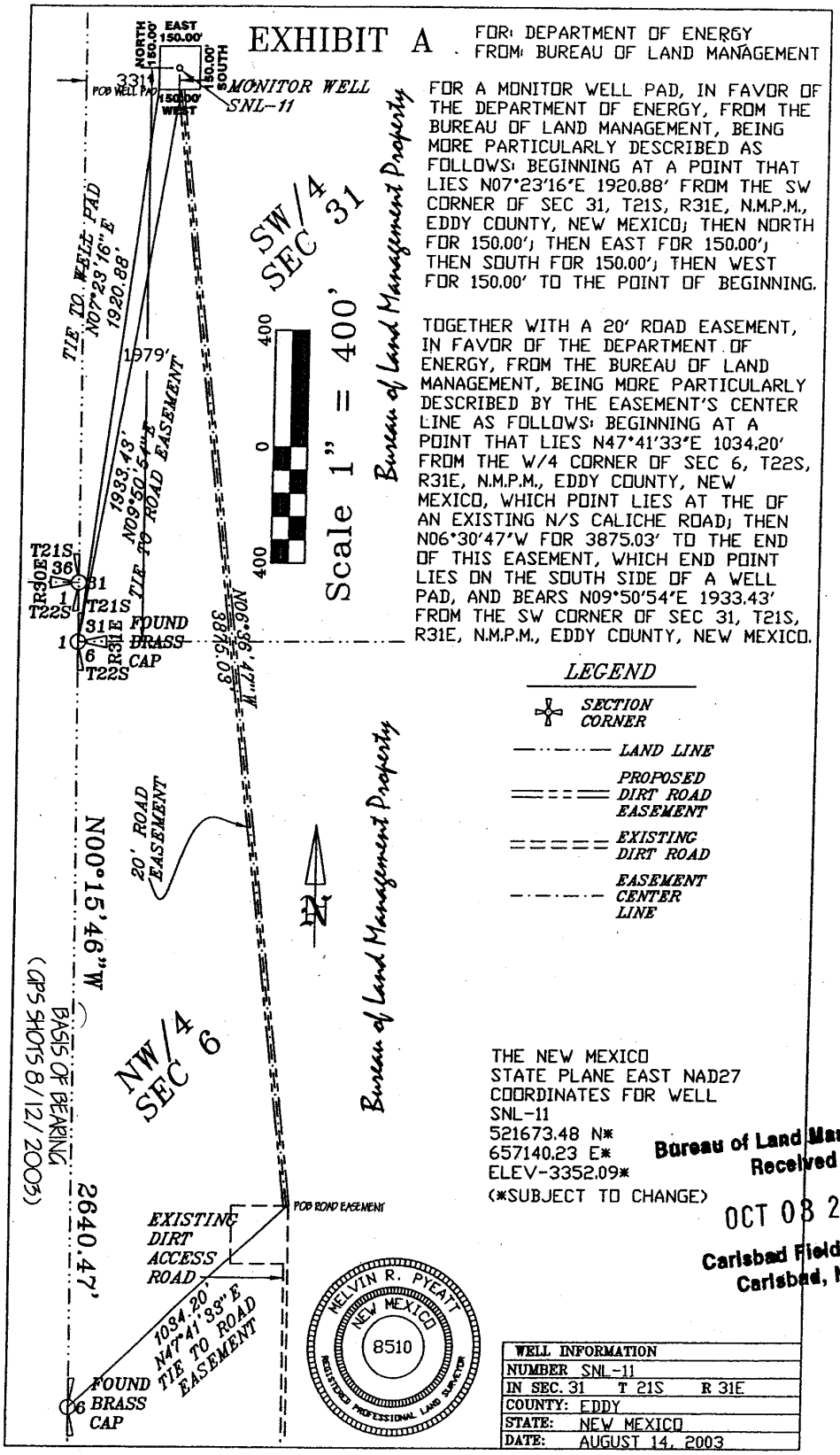


Figure 1. Project Area Map

NM-110735



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Carlsbad, N.M.

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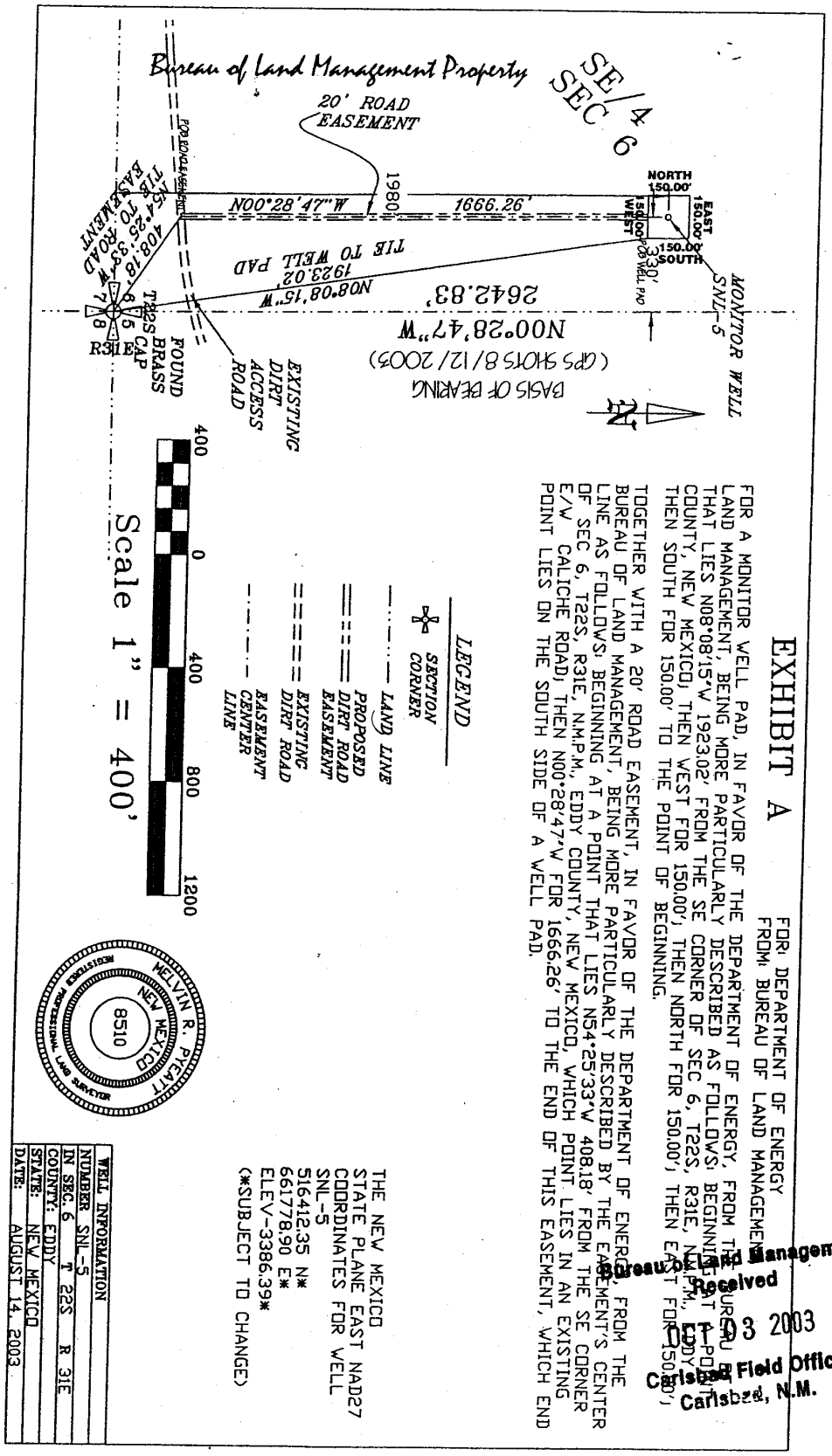

EXHIBIT A

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 N08°08'15"W 1923.02' FROM THE SE CORNER OF SEC 6, T22S, R31E, N.M.P.M., EDDY COUNTY, NEW MEXICO, THEN WEST FOR 150.00', THEN NORTH FOR 150.00', THEN EAST FOR 150.00', THEN SOUTH FOR 150.00' TO THE POINT OF BEGINNING.

TOGETHER WITH A 20' ROAD EASEMENT, IN FAVOR OF THE DEPARTMENT OF ENERGY, FROM THE BUREAU OF LAND MANAGEMENT, BEING MORE PARTICULARLY DESCRIBED BY THE EASEMENT'S CENTER LINE AS FOLLOWS; BEGINNING AT A POINT THAT LIES N54°25'33"W 408.18' FROM THE SE CORNER OF SEC 6, T22S, R31E, N.M.P.M., EDDY COUNTY, NEW MEXICO, WHICH POINT LIES IN AN EXISTING E/W CALICHE ROAD, THEN N00°28'47"W FOR 1666.26' TO THE END OF THIS EASEMENT, WHICH END POINT LIES ON THE SOUTH SIDE OF A WELL PAD.

THE NEW MEXICO STATE PLANE EAST NAD27 COORDINATES FOR WELL SNL-5
516412.35 N*
661778.90 E*
ELEV-3386.39*
(*SUBJECT TO CHANGE)

WELL INFORMATION	
NUMBER	SNL-5
IN SEC 6	T 22S R 31E
COUNTY: EDDY	
STATE: NEW MEXICO	
DATE: AUGUST 14, 2003	

Bureau of Land Management
Received
OCT 03 2003
Field Office
Carlsbad, N.M.

Appendix F
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:** 84911
4. Type of Report: **Negative (X)** **Positive ( )**		
5. Title of Report: Addendum to MFS-908 "A Class III Cultural Resource Survey for the SNL-5 Water Well"		**6. Fieldwork Date(s):** 2 September 2003
Author(s): Justin Rein		**7. Report Date:** 2 September 2003
8. Consultant Name/Address: Mesa Field Services **Direct Charge:** Theresa Straight **Field Personnel Names:** Justin Rein **Address:** P.O. Box 3072 Carlsbad, New Mexico 88221-3072 **Phone (**505**)** 628-8885		**9. Cultural Resource Permit No.:** 153-2920-03-M **10. Consultant Report No.:** MFS-908a
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.:** Purchase Order No. 107596

13. Land Status	**BLM**	**State**	**Private**	**Other**	**Total**
a. Area Surveyed (acres)	8.55				8.55
b. Area of Effect (acres)	1.29				1.29

14. Linear Survey **Length** 1,666.26 feet **Width** 150 feet
Block Survey **Length** 350 feet **Width** 350 feet

15. Location (Map[s] Attached):

a. State: New Mexico

b. County: Eddy County

c. BLM Office: Carlsbad

d. Nearest City or Town: Carlsbad, New Mexico

e. Legal Description: T 22 S, R 31 E, Section 6: E½ SE¼

f. Well Pad Footages: The proposed water well is centered 330 feet from the east line and 1,980 feet from the south line of Section 6.

g. USGS 7.5' Map Name(s), Date(s), and Code(s): Livingston Ridge, NM Provisional Edition 1985 (32103-D7)

16. Project Data:

a. Records Search: **Date(s) of BLM File Review:** 2 September 2003 **Name of Reviewer(s):** Justin Rein
Date(s) of ARMS Data Review: 2 September 2003 **Name of Reviewer(s):** Justin Rein
Findings (see Field Office requirements to determine area to be reviewed during records search): No sites were found to be within 0.25 miles of the project area.

b. Description of Undertaking: Westinghouse TRU Solutions, LLC plans to install a water monitoring well in Township 22 South, Range 31 East, Section 6. The proposed monitoring well was relocated to the current location after an initial survey on July 22, 2003. The current well is centered 330 feet from the east line and 1,980 feet from the south line of Section 6. The pad to be constructed will measure 150 ft square. To ensure the protection of cultural resources, a 350 ft square block was surveyed. The access road will begin at an existing caliche capped road and travel north 1,666.26 ft to the well location. The impact corridor for the road is 20 ft wide, yet a 150 ft wide corridor was surveyed to protect cultural resources. The project area is located entirely on federal land owned and administered by the Bureau of Land Management-Carlsbad Field Office.

c. Environmental Setting (NRCS soil designation; vegetative community; elevation; etc.): The project area is located approximately 5 miles north of the Waste Isolation Pilot Plant (WIPP) facility in a dune field. The project elevation averages 3,380 ft above mean sea level. The light brown sandy soils have been wind worked into dunes up to 1.5 m high with some dunes to 3 m high. These soils are of the Kermit-Berino association as defined by the Soil Conservation Service of the U.S. Department of Agriculture. Local vegetation includes shin oak, mesquite, sand sage, four-wing salt bush, prickly pear, grasses, and forbs. Due to this vegetative cover, ground surface visibility averaged 70 percent at the time of the survey. The project area is located on a plain with a grade of less than one percent down to the west. According to the Western Regional Climate Center, the WIPP facility received an average 12.76 inches of rain from 1986 to 2001. The project area has been impacted primarily by cattle ranching activities.

d. Field Methods (transect intervals; crew size; time in field; etc.): A crew of one spent 2 hours surveying the project area. A 15 m transect interval was used.

e. Artifacts Collected?: None

17. Cultural Resource Findings: N/A

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

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

18. Management Summary (Recommendations): Archaeological clearance is recommended for the project as staked. If any cultural materials are encountered during construction activities, work at that location should stop immediately and archaeologists at 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.

Addendum to " A Survey for the SNL-5 Water Well"

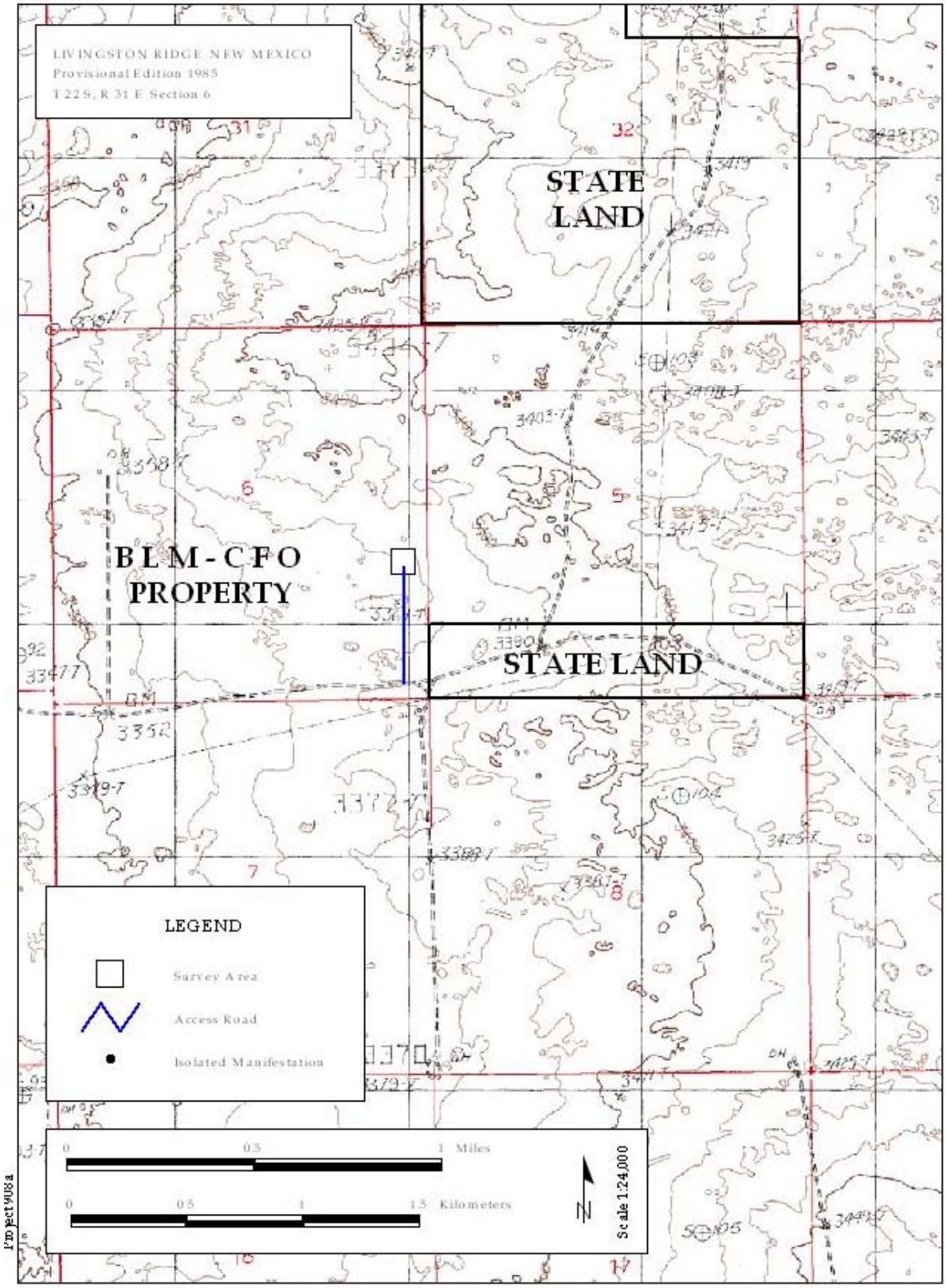

Figure 1. Project Area Map **Mesa Field Services**

Appendix G
Photograph Logs

Digital photographs were taken of the cores from SNL-5. These photographs have been compiled into a listing of consecutive photos beginning with the uppermost core (lower Forty-niner Member of the Rustler Formation) and ending with the lowermost (upper Los Medaños Member of the Rustler Formation). The photographs were taken in the field shortly after recovery. A CD-ROM with these images (jpeg format) is being archived, and a copy with photographic log is maintained by Geotechnical Engineering (Washington TRU Solutions LLC) with records of the cores stored for WIPP.

Photograph Log Sheet

File	DATE	LOCATION	DESCRIPTION OF SUBJECT (includes individual/group names, direction, etc. as appropriate)	PHOTOGRAPHER (initials and dept.)
SNL-5_Core001.jpg	5-03-04	SNL-5 drillpad; T22S, R31E, sec 6	Close-up photo of Forty-niner Mbr core, 512.0 - 513.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-5_Core002.jpg	5-03-04	SNL-5 drillpad; T22S, R31E, sec 6	Close-up photo of Forty-niner Mbr core, 513.0 - 514.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-5_Core003.jpg	5-03-04	SNL-5 drillpad; T22S, R31E, sec 6	Close-up photo of Forty-niner / Magenta Dolomite Mbrs core, 514.0 - 515.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-5_Core004.jpg	5-03-04	SNL-5 drillpad; T22S, R31E, sec 6	Close-up photo of Magenta Dolomite Mbr core, 514.0 - 515.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-5_Core005.jpg	5-03-04	SNL-5 drillpad; T22S, R31E, sec 6	Close-up photo of Magenta Dolomite Mbr core, 516.0 - 517.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-5_Core006.jpg	5-03-04	SNL-5 drillpad; T22S, R31E, sec 6	Close-up photo of Magenta Dolomite Mbr core, 517.0 - 518.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-5_Core007.jpg	5-03-04	SNL-5 drillpad; T22S, R31E, sec 6	Close-up photo of Magenta Dolomite Mbr core, 518.0 - 519.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-5_Core008.jpg	5-03-04	SNL-5 drillpad; T22S, R31E, sec 6	Close-up photo of Magenta Dolomite Mbr core, 519.0 - 520.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-5_Core009.jpg	5-03-04	SNL-5 drillpad; T22S, R31E, sec 6	Close-up photo of Magenta Dolomite Mbr core, 520.0 - 521.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-5_Core010.jpg	5-03-04	SNL-5 drillpad; T22S, R31E, sec 6	Close-up photo of Magenta Dolomite Mbr core, 521.0 - 522.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-5_Core011.jpg	5-03-04	SNL-5 drillpad; T22S, R31E, sec 6	Close-up photo of Magenta Dolomite Mbr core, 522.0 - 523.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-5_Core012.jpg	5-03-04	SNL-5 drillpad; T22S, R31E, sec 6	Close-up photo of Magenta Dolomite Mbr core, 523.1 - 524.2 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-5_Core013.jpg	5-03-04	SNL-5 drillpad; T22S, R31E, sec 6	Close-up photo of Magenta Dolomite Mbr core, 524.1 - 525.2 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-5_Core014.jpg	5-03-04	SNL-5 drillpad; T22S, R31E, sec 6	Close-up photo of Magenta Dolomite Mbr core, 525.2 - 526.2 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-5_Core015.jpg	5-03-04	SNL-5 drillpad; T22S, R31E, sec 6	Close-up photo of Magenta Dolomite Mbr core, 525.9 - 527.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-5_Core016.jpg	5-03-04	SNL-5 drillpad; T22S, R31E, sec 6	Close-up photo of Magenta Dolomite Mbr core, 596.9 - 528.1 ft bgl, with markings, scale	DW Powers Consultant to WTS

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

Photograph Log Sheet

File	DATE	LOCATION	DESCRIPTION OF SUBJECT (includes individual/group names, direction, etc. as appropriate)	PHOTOGRAPHER (initials and dept.)
SNL-5_Core017.jpg	5-03-04	SNL-5 drillpad; T22S, R31E, sec 6	Close-up photo of Magenta Dolomite Mbr core, 527.9 - 529.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-5_Core018.jpg	5-03-04	SNL-5 drillpad; T22S, R31E, sec 6	Close-up photo of Magenta Dolomite Mbr core, 528.9 - 530.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-5_Core019.jpg	5-03-04	SNL-5 drillpad; T22S, R31E, sec 6	Close-up photo of Magenta Dolomite Mbr core, 529.9 - 531.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-5_Core020.jpg	5-03-04	SNL-5 drillpad; T22S, R31E, sec 6	Close-up photo of Magenta Dolomite Mbr core, 530.9 - 532.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-5_Core021.jpg	5-03-04	SNL-5 drillpad; T22S, R31E, sec 6	Close-up photo of Magenta Dolomite Mbr core, 531.9 - 533.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-5_Core022.jpg	5-03-04	SNL-5 drillpad; T22S, R31E, sec 6	Close-up photo of Magenta Dolomite Mbr core, 532.9 - 534.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-5_Core023.jpg	5-03-04	SNL-5 drillpad; T22S, R31E, sec 6	Close-up photo of Magenta Dolomite Mbr core, 533.9 - 535.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-5_Core024.jpg	5-03-04	SNL-5 drillpad; T22S, R31E, sec 6	Close-up photo of Magenta Dolomite Mbr core, 534.9 - 536.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-5_Core025.jpg	5-03-04	SNL-5 drillpad; T22S, R31E, sec 6	Close-up photo of Magenta Dolomite Mbr core, 535.9 - 537.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-5_Core026.jpg	5-03-04	SNL-5 drillpad; T22S, R31E, sec 6	Close-up photo of Magenta Dolomite Mbr core, 536.9 - 538.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-5_Core027.jpg	5-03-04	SNL-5 drillpad; T22S, R31E, sec 6	Close-up photo of Magenta Dolomite / Tamarisk Mbrs core, 537.9 - 539.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-5_Core028.jpg	5-03-04	SNL-5 drillpad; T22S, R31E, sec 6	Close-up photo of Tamarisk Mbr core, 538.9 - 540.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-5_Core029.jpg	5-03-04	SNL-5 drillpad; T22S, R31E, sec 6	Close-up photo of Tamarisk Mbr core, 539.9 - 541.2 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-5_Core030.jpg	5-03-04	SNL-5 drillpad; T22S, R31E, sec 6	Close-up photo of Tamarisk Mbr core, 540.9 - 542.0 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-5_Core031.jpg	5-04-04	SNL-5 drillpad; T22S, R31E, sec 6	Close-up photo of Tamarisk Mbr core, 598.0 - 599.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-5_Core032.jpg	5-04-04	SNL-5 drillpad; T22S, R31E, sec 6	Close-up photo of Tamarisk Mbr core, 599.0 - 600.1 ft bgl, with markings, scale	DW Powers Consultant to WTS

Camera: Nikon CoolPix 5700 **Resolution**: 2560 x 1920 **Page 2 of 8**

Photograph Log Sheet

File	DATE	LOCATION	DESCRIPTION OF SUBJECT (includes individual/group names, direction, etc. as appropriate)	PHOTOGRAPHER (initials and dept.)
SNL-5_Core033.jpg	5-04-04	SNL-5 drillpad; T22S, R31E, sec 6	Close-up photo of Tamarisk Mbr core, 600.0 - 601.12 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-5_Core034.jpg	5-04-04	SNL-5 drillpad; T22S, R31E, sec 6	Close-up photo of Tamarisk Mbr core, 601.0 - 602.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-5_Core035.jpg	5-04-04	SNL-5 drillpad; T22S, R31E, sec 6	Close-up photo of Tamarisk Mbr core, 602.0 - 603.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-5_Core036.jpg	5-04-04	SNL-5 drillpad; T22S, R31E, sec 6	Close-up photo of Tamarisk Mbr core, 603.0 - 604.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-5_Core037.jpg	5-04-04	SNL-5 drillpad; T22S, R31E, sec 6	Close-up photo of Tamarisk Mbr core, 604.0 - 605.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-5_Core038.jpg	5-04-04	SNL-5 drillpad; T22S, R31E, sec 6	Close-up photo of Tamarisk Mbr core, 605.0 - 606.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-5_Core039.jpg	5-04-04	SNL-5 drillpad; T22S, R31E, sec 6	Close-up photo of Tamarisk Mbr core, 606.0 - 607.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-5_Core040.jpg	5-04-04	SNL-5 drillpad; T22S, R31E, sec 6	Close-up photo of Tamarisk Mbr core, 607.0 - 608.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-5_Core041.jpg	5-04-04	SNL-5 drillpad; T22S, R31E, sec 6	Close-up photo of Tamarisk Mbr core, 608.0 - 609.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-5_Core042.jpg	5-04-04	SNL-5 drillpad; T22S, R31E, sec 6	Close-up photo of Tamarisk Mbr core, 609.0 - 610.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-5_Core043.jpg	5-04-04	SNL-5 drillpad; T22S, R31E, sec 6	Close-up photo of Tamarisk Mbr core, 610.0 - 610.5 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-5_Core044.jpg	5-04-04	SNL-5 drillpad; T22S, R31E, sec 6	Close-up photo of Tamarisk Mbr core, 610.5 - 611.4ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-5_Core045.jpg	5-04-04	SNL-5 drillpad; T22S, R31E, sec 6	Close-up photo of Tamarisk Mbr core, 610.9 - 612.3 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-5_Core046.jpg	5-04-04	SNL-5 drillpad; T22S, R31E, sec 6	Close-up photo of Tamarisk Mbr core, 611.8 - 613.2 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-5_Core047.jpg	5-04-04	SNL-5 drillpad; T22S, R31E, sec 6	Close-up photo of Tamarisk Mbr core, 612.9 - 614.3 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-5_Core048.jpg	5-04-04	SNL-5 drillpad; T22S, R31E, sec 6	Close-up photo of Tamarisk Mbr core, 613.9 - 615.3 ft bgl, with markings, scale	DW Powers Consultant to WTS

Camera: Nikon CoolPix 5700 **Resolution**: 2560 x 1920 **Page 3 of 8**

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File	DATE	LOCATION	DESCRIPTION OF SUBJECT (includes individual/group names, direction, etc. as appropriate)	PHOTOGRAPHER (initials and dept.)
SNL-5_Core049.jpg	5-04-04	SNL-5 drillpad; T22S, R31E, sec 6	Close-up photo of Tamarisk Mbr core, 614.9 - 616.3 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-5_Core050.jpg	5-04-04	SNL-5 drillpad; T22S, R31E, sec 6	Close-up photo of Tamarisk Mbr core, 615.9 - 617.3 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-5_Core051.jpg	5-04-04	SNL-5 drillpad; T22S, R31E, sec 6	Close-up photo of Tamarisk Mbr core, 616.9 - 618.3 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-5_Core052.jpg	5-04-04	SNL-5 drillpad; T22S, R31E, sec 6	Close-up photo of Tamarisk Mbr core, 617.9 - 619.3 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-5_Core053.jpg	5-04-04	SNL-5 drillpad; T22S, R31E, sec 6	Close-up photo of Tamarisk Mbr core, 618.9 - 620.3 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-5_Core054.jpg	5-04-04	SNL-5 drillpad; T22S, R31E, sec 6	Close-up photo of Tamarisk Mbr core, 619.9 - 621.3 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-5_Core055.jpg	5-04-04	SNL-5 drillpad; T22S, R31E, sec 6	Close-up photo of Tamarisk Mbr core, 620.9 - 622.3 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-5_Core056.jpg	5-04-04	SNL-5 drillpad; T22S, R31E, sec 6	Close-up photo of Tamarisk Mbr core, 621.9 - 623.3 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-5_Core057.jpg	5-04-04	SNL-5 drillpad; T22S, R31E, sec 6	Close-up photo of Tamarisk Mbr core, 622.9 - 624.3 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-5_Core058.jpg	5-04-04	SNL-5 drillpad; T22S, R31E, sec 6	Close-up photo of Tamarisk Mbr core, 623.9 - 625.3 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-5_Core059.jpg	5-04-04	SNL-5 drillpad; T22S, R31E, sec 6	Close-up photo of Tamarisk Mbr core, 624.8 - 626.3 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-5_Core060.jpg	5-04-04	SNL-5 drillpad; T22S, R31E, sec 6	Close-up photo of Tamarisk Mbr core, 625.9 - 627.3 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-5_Core061.jpg	5-05-04	SNL-5 drillpad; T22S, R31E, sec 6	Close-up photo of Tamarisk Mbr core, 627.3 - 628.2 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-5_Core062.jpg	5-05-04	SNL-5 drillpad; T22S, R31E, sec 6	Close-up photo of Tamarisk Mbr core, 627.9 - 629.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-5_Core063.jpg	5-05-04	SNL-5 drillpad; T22S, R31E, sec 6	Close-up photo of Tamarisk Mbr core, 628.9 - 630.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-5_Core064.jpg	5-05-04	SNL-5 drillpad; T22S, R31E, sec 6	Close-up photo of Tamarisk Mbr core, 629.9 - 631.1 ft bgl, with markings, scale	DW Powers Consultant to WTS

Camera: Nikon CoolPix 5700 **Resolution**: 2560 x 1920 **Page 4 of 8**

Photograph Log Sheet

File	DATE	LOCATION	DESCRIPTION OF SUBJECT (includes individual/group names, direction, etc. as appropriate)	PHOTOGRAPHER (initials and dept.)
SNL-5_Core065.jpg	5-05-04	SNL-5 drillpad; T22S, R31E, sec 6	Close-up photo of Tamarisk Mbr core, 630.9 - 632.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-5_Core066.jpg	5-05-04	SNL-5 drillpad; T22S, R31E, sec 6	Close-up photo of Tamarisk Mbr core, 631.9 - 633.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-5_Core067.jpg	5-05-04	SNL-5 drillpad; T22S, R31E, sec 6	Close-up photo of Tamarisk Mbr core, 632.9 - 634.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-5_Core068.jpg	5-05-04	SNL-5 drillpad; T22S, R31E, sec 6	Close-up photo of Tamarisk / Culebra Dolomite Mbrs core, 633.9 - 635.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-5_Core069.jpg	5-05-04	SNL-5 drillpad; T22S, R31E, sec 6	Close-up photo of Culebra Dolomite Mbr core, 634.9 - 636.1 ft bgl, with scale	DW Powers Consultant to WTS
SNL-5_Core070.jpg	5-05-04	SNL-5 drillpad; T22S, R31E, sec 6	Close-up photo of Culebra Dolomite Mbr core, 636.9 - 637.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-5_Core071.jpg	5-05-04	SNL-5 drillpad; T22S, R31E, sec 6	Close-up photo of Culebra Dolomite Mbr core, 636.9 - 638.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-5_Core072.jpg	5-05-04	SNL-5 drillpad; T22S, R31E, sec 6	Close-up photo of Culebra Dolomite Mbr core,638.0 - 639.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-5_Core073.jpg	5-05-04	SNL-5 drillpad; T22S, R31E, sec 6	Close-up photo of Culebra Dolomite Mbr core, 639.0 - 640.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-5_Core074.jpg	5-05-04	SNL-5 drillpad; T22S, R31E, sec 6	Close-up photo of Culebra Dolomite Mbr core, 640.0 - 641.2 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-5_Core075.jpg	5-05-04	SNL-5 drillpad; T22S, R31E, sec 6	Close-up photo of Culebra Dolomite Mbr core, 641.0 - 642.2 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-5_Core076.jpg	5-05-04	SNL-5 drillpad; T22S, R31E, sec 6	Close-up photo of Culebra Dolomite Mbr core, 642.0 - 643.2 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-5_Core077.jpg	5-05-04	SNL-5 drillpad; T22S, R31E, sec 6	Close-up photo of Culebra Dolomite Mbr core, 643.0 - 644.2 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-5_Core078.jpg	5-05-04	SNL-5 drillpad; T22S, R31E, sec 6	Close-up photo of Culebra Dolomite Mbr core, 644.2 - 645.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-5_Core079.jpg	5-05-04	SNL-5 drillpad; T22S, R31E, sec 6	Close-up photo of Culebra Dolomite Mbr core, 644.9 - 646.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-5_Core080.jpg	5-05-04	SNL-5 drillpad; T22S, R31E, sec 6	Close-up photo of Culebra Dolomite Mbr core, 645.9 - 647.1 ft bgl, with markings, scale	DW Powers Consultant to WTS

Camera: Nikon CoolPix 5700 **Resolution**: 2560 x 1920 **Page 5 of 8**

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File	DATE	LOCATION	DESCRIPTION OF SUBJECT (includes individual/group names, direction, etc. as appropriate)	PHOTOGRAPHER (initials and dept.)
SNL-5_Core081.jpg	5-05-04	SNL-5 drillpad; T22S, R31E, sec 6	Close-up photo of Culebra Dolomite Mbr core, 646.9 - 648.2 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-5_Core082.jpg	5-05-04	SNL-5 drillpad; T22S, R31E, sec 6	Close-up photo of Culebra Dolomite Mbr core, 647.9 - 649.2 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-5_Core083.jpg	5-05-04	SNL-5 drillpad; T22S, R31E, sec 6	Close-up photo of Culebra Dolomite Mbr core, 648.9 - 650.2 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-5_Core084.jpg	5-05-04	SNL-5 drillpad; T22S, R31E, sec 6	Close-up photo of Culebra Dolomite Mbr core, 649.9 - 651.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-5_Core085.jpg	5-05-04	SNL-5 drillpad; T22S, R31E, sec 6	Close-up photo of Culebra Dolomite Mbr core, 650.9 - 652.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-5_Core086.jpg	5-05-04	SNL-5 drillpad; T22S, R31E, sec 6	Close-up photo of Culebra Dolomite Mbr core, 651.9 - 653.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-5_Core087.jpg	5-05-04	SNL-5 drillpad; T22S, R31E, sec 6	Close-up photo of Culebra Dolomite Mbr core, 652.9 - 654.2 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-5_Core088.jpg	5-05-04	SNL-5 drillpad; T22S, R31E, sec 6	Close-up photo of Culebra Dolomite Mbr core, 653.9 - 655.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-5_Core089.jpg	5-05-04	SNL-5 drillpad; T22S, R31E, sec 6	Close-up photo of Culebra Dolomite Mbr core, 654.9 - 656.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-5_Core090.jpg	5-05-04	SNL-5 drillpad; T22S, R31E, sec 6	Close-up photo of Culebra Dolomite Mbr core, 656.1- ~657 ft bgl, unmarked pieces	DW Powers Consultant to WTS
SNL-5_Core091.jpg	5-05-04	SNL-5 drillpad; T22S, R31E, sec 6	Close-up photo of Culebra Dolomite Mbr core, ~657 - ~657.3 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-5_Core092.jpg	5-05-04	SNL-5 drillpad; T22S, R31E, sec 6	Close-up photo of Culebra Dolomite / Los Medaños Mbr core, 657.3 - 658.2 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-5_Core093.jpg	5-05-04	SNL-5 drillpad; T22S, R31E, sec 6	Close-up photo of Los Medaños Mbr core, 658.0 - 659.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-5_Core094.jpg	5-05-04	SNL-5 drillpad; T22S, R31E, sec 6	Close-up photo of Los Medaños Mbr core, 659.0 - 660.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-5_Core095.jpg	5-05-04	SNL-5 drillpad; T22S, R31E, sec 6	Close-up photo of Los Medaños Mbr core, 660.0 - 661.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-5_Core096.jpg	5-05-04	SNL-5 drillpad; T22S, R31E, sec 6	Close-up photo of Los Medaños Mbr core, 661.0 - 662.1 ft bgl, with markings, scale	DW Powers Consultant to WTS

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File	DATE	LOCATION	DESCRIPTION OF SUBJECT (includes individual/group names, direction, etc. as appropriate)	PHOTOGRAPHER (initials and dept.)
SNL-5_Core097.jpg	5-05-04	SNL-5 drillpad; T22S, R31E, sec 6	Close-up photo of Los Medaños Mbr core, 662.0 - 663.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-5_Core098.jpg	5-05-04	SNL-5 drillpad; T22S, R31E, sec 6	Close-up photo of Los Medaños Mbr core, 663.0 - 664.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-5_Core099.jpg	5-05-04	SNL-5 drillpad; T22S, R31E, sec 6	Close-up photo of Los Medaños Mbr core, 664.0 - 665.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-5_Core100.jpg	5-05-04	SNL-5 drillpad; T22S, R31E, sec 6	Close-up photo of Los Medaños Mbr core, 665.0 - 666.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-5_Core101.jpg	5-05-04	SNL-5 drillpad; T22S, R31E, sec 6	Close-up photo of Los Medaños Mbr core, 666.0 - 667.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-5_Core102.jpg	5-05-04	SNL-5 drillpad; T22S, R31E, sec 6	Close-up photo of Los Medaños Mbr core, 667.0 - 668.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-5_Core103.jpg	5-05-04	SNL-5 drillpad; T22S, R31E, sec 6	Close-up photo of Los Medaños Mbr core, 668.0 - 669.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-5_Core104.jpg	5-05-04	SNL-5 drillpad; T22S, R31E, sec 6	Close-up photo of Los Medaños Mbr core, 669.0 - 670.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-5_Core105.jpg	5-05-04	SNL-5 drillpad; T22S, R31E, sec 6	Close-up photo of Los Medaños Mbr core, 670.0 - 671.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-5_Core106.jpg	5-05-04	SNL-5 drillpad; T22S, R31E, sec 6	Close-up photo of Los Medaños Mbr core, 671.1 - 672.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-5_Core107.jpg	5-05-04	SNL-5 drillpad; T22S, R31E, sec 6	Close-up photo of Los Medaños Mbr core, 672.0 - 673.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-5_Core108.jpg	5-05-04	SNL-5 drillpad; T22S, R31E, sec 6	Close-up photo of Los Medaños Mbr core, 673.0 - 674.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-5_Core109.jpg	5-05-04	SNL-5 drillpad; T22S, R31E, sec 6	Close-up photo of Los Medaños Mbr core, 674.0 - 675.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-5_Core110.jpg	5-05-04	SNL-5 drillpad; T22S, R31E, sec 6	Close-up photo of Los Medaños Mbr core, 675.0 - 676.1 ft bgl, with scale	DW Powers Consultant to WTS
SNL-5_Core111.jpg	5-05-04	SNL-5 drillpad; T22S, R31E, sec 6	Close-up photo of Los Medaños Mbr core, 676.0 - 677.1 ft bgl, with scale	DW Powers Consultant to WTS
SNL-5_Core112.jpg	5-05-04	SNL-5 drillpad; T22S, R31E, sec 6	Close-up photo of Los Medaños Mbr core, 677.0 - 678.1 ft bgl, with markings, scale	DW Powers Consultant to WTS

Camera: Nikon CoolPix 5700 **Resolution**: 2560 x 1920 **Page 7 of 8**

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File	DATE	LOCATION	DESCRIPTION OF SUBJECT (includes individual/group names, direction, etc. as appropriate)	PHOTOGRAPHER (initials and dept.)
SNL-5_Core113.jpg	5-05-04	SNL-5 drillpad; T22S, R31E, sec 6	Close-up photo of Los Medaños Mbr core, 678.0 - 679.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-5_Core114.jpg	5-05-04	SNL-5 drillpad; T22S, R31E, sec 6	Close-up photo of Los Medaños Mbr core, 679.0 - 680.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-5_Core115.jpg	5-05-04	SNL-5 drillpad; T22S, R31E, sec 6	Close-up photo of Los Medaños Mbr core, 680.0 - 681.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-5_Core116.jpg	5-05-04	SNL-5 drillpad; T22S, R31E, sec 6	Close-up photo of Los Medaños Mbr core, 681.0 - 682.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-5_Core117.jpg	5-05-04	SNL-5 drillpad; T22S, R31E, sec 6	Close-up photo of Los Medaños Mbr core, 682.0 - 683.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-5_Core118.jpg	5-05-04	SNL-5 drillpad; T22S, R31E, sec 6	Close-up photo of Los Medaños Mbr core, 683.0 - 684.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-5_Core119.jpg	5-05-04	SNL-5 drillpad; T22S, R31E, sec 6	Close-up photo of Los Medaños Mbr core, 684.0 - 685.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-5_Core120.jpg	5-05-04	SNL-5 drillpad; T22S, R31E, sec 6	Close-up photo of Los Medaños Mbr core, 685.0 - 686.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-5_Core121.jpg	5-05-04	SNL-5 drillpad; T22S, R31E, sec 6	Close-up photo of Los Medaños Mbr core, 686.0 - 687.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-5_Core122.jpg	5-05-04	SNL-5 drillpad; T22S, R31E, sec 6	Close-up photo of Los Medaños Mbr core, 687.0 - 687.3 ft bgl, with markings, scale	DW Powers Consultant to WTS

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