DOE/WIPP 04-3301

Basic Data Report For Drillhole SNL-1 (C-2953) (Waste Isolation Pilot Plant)

March to August 2004

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Basic Data Report
For Drillhole SNL-1 (C-2953)
(Waste Isolation Pilot Plant)

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March to August 2004

West Texas Water Well Service Rig #15 at SNL-1, viewed toward the south. The Waste Handling Shaft for the Waste Isolation Pilot Plant is on the horizon, at the center. The rig is set up for coring with water, which discharges into a portable mud pit. Taken March 29, 2004, by Dennis W. Powers.

EXECUTIVE SUMMARY

SNL-1 (permitted by the New Mexico State Engineer as C-2953) was drilled to provide geological data and hydrological testing of the Culebra Dolomite Member of the Permian Rustler Formation near the margin of dissolution of halite in the upper Permian Salado Formation in the northeast arm of Nash Draw. SNL-1 is located in the northwest quarter of section 16, T21S, R31E, in eastern Eddy County, New Mexico, and is adjacent to the tailings pile of Mississippi Potash Incorporated (now Intrepid) East mine to test for the presence of shallow saturated zones that might include brine infiltrated from the tailings pile. SNL-1 was drilled to a total depth of 644 ft below ground level (bgl). Below surface wash, SNL-1 encountered, in order, the Mescalero caliche, Dewey Lake, and Rustler Formations. Two intervals were cored: (1) from the lower Forty-niner Member through the Magenta Dolomite and into the upper Tamarisk Member; and (2) from the lower Tamarisk Member through the Culebra Dolomite and into the upper Los Medaños Member. Geophysical logs were acquired from the open hole at total depth.

The uppermost Los Medaños has normal lithology, thickness, and stratigraphic sequence; the upper claystone under the Culebra is deformed, as it is in many other locations. Core recovery was excellent from the upper mudstone of the Los Medaños, and no halite was encountered, which is consistent with earlier studies. The studies suggest that halite may be present in the lower Los Medaños, but it was not drilled or cored. At about 30 ft, the Culebra Dolomite is a little thicker than average. Core recovery was poor, but recovered core shows bedding and porosity similar to other Culebra cores. Core was lost from most of the lower Culebra, which is usually the most porous and transmissive part of the unit. Indurated reddish-brown mudstone with some coarse particles fills some larger porosity in the upper Culebra. The bit and drilling pipe dropped ~2 ft at a depth of about 615 ft, indicating open porosity. Circulation was lost at this depth and was only partially recovered as the hole was deepened. Approximately 550 barrels of water were lost during drilling. Recovered samples from the lower Culebra included grayish clay and claystone, and the natural gamma log is consistent with increased clay content from ~620–624 ft. The Tamarisk has a normal stratigraphic sequence and thickness. The basal sulfate unit includes horizontal reddish-brown mud laminae and fracture fill. The mudstone unit shows mostly reddish-brown sandy claystone with some gray mottling; gray and reddish-brown siltstone at the top of the unit is more limited than in many cores. Angular clasts or fragments of gypsum are included, with displacive gypsum laths present in the upper part of the unit. The upper Tamarisk sulfate includes possible carbonate and algal bedding near the base. The Magenta Dolomite is about 27 ft thick and shows typical laminar to wavy bedding, some ripples, and algal stromatolites. A few near-vertical fractures were preserved in cores. Cores and geophysical logs indicate some porosity in the upper part of the Magenta. The Forty-niner is represented by a typical sulfate–mudstone–sulfate sequence. Carbonate interbeds in the basal sulfate above the Magenta indicate depositional environments fluctuated over time before sulfate dominated. Some of the Dewey Lake was eroded at some time before the Pleistocene Mescalero caliche was formed. Cuttings indicate that the sulfate–carbonate cement transition in the Dewey Lake is about 350 ft bgl at SNL-1. 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. Neither Triassic Santa Rosa nor Mio-Pleistocene Gatuña Formation is distinguishable at SNL-1. The Mescalero caliche is disturbed and poorly formed around the drillpad area, and the draw south of the drillpad shows more recent fill and soil development.

Moist cuttings were encountered beginning at about 15 ft. Drilling was halted at 36 ft, and water entered the hole. Water level changes were monitored for about 2 hours; the last depth measured was 31.2 ft below the drilling pad surface, but levels were still rising. Specific gravity of the water was 1.21 g/cc (grams per cubic centimeter),

measured in the field. Fresh water was used to drill the hole from 36 ft, and this precluded significant observations of saturated zones below this point.

SNL-1 was drilled (and reamed through cored intervals) with an original diameter of 11 inches to total depth, and this diameter was sufficient to complete the hole without additional reaming. Fiberglass reinforced plastic casing (4.83 inches outside diameter) was placed in the hole, with a screen interval across the Culebra Dolomite from 593.75–620 ft below the top of the connector on the conductor casing. Approximately 2 ft of fiberglass reinforced plastic casing was left above the connector. The annulus was filled with 8/16 Brady sand to 584 ft, above the Culebra, and bentonite was placed to 579 ft to separate the Culebra from the Tamarisk mudstone. The annulus above the bentonite was cemented to the surface. Water and sediment were bailed from the well.

SNL-1 was cleaned April 15, 2004, by jetting at 200 psi with ~112 barrels of water. On April 16, 2004, the well was pumped for 6.67 hours at a rate of ~15 gallons per minute (GPM). On April 20, 2004, SNL-1 was pumped for 3 hours at 13 gpm, and the final fluid density was 1.025 g/cc. On May 12, 2004, the measured water level from the Culebra was 3,071.69 ft above mean sea level (amsl), and the fresh-water-equivalent level was 3,077.17 ft amsl. Since May, water levels have dropped slightly and remain steady.

West Texas Water Well Service crew tallying the length of each joint of fiberglass reinforced plastic casing used to complete SNL-1. Ronnie Keith at left, Luis Armendariz, center, and Donnie Basile at upper right.

Table of Contents

List of Figures and Tables

In keeping with practice at the WIPP site, the basic data for SNL-1 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)

Preparing 4-inch core barrel at SNL-1 (above) with diamond core bit (right). John Wood (above, lower right) from Diamond Oil Well Drilling Company is assisted by West Texas Water Well Service personnel (from left: Luis Armendariz, Josh Bowman, and Gil Gillespie).

1.0 INTRODUCTION

SNL-1 was drilled in the northwest quarter of Section 16, T21S, R31E, in eastern Eddy County, New Mexico (Fig. 1-1). It is located 3842 ft from the south line (fsl) and 535 ft from the west line (fwl) of the section (Fig. 1-2). This location places the drillhole on the east side of the escarpment in the northeast arm of Nash Draw and immediately south of the tailings pile at the East mine of Intrepid Mining New Mexico LLC (formerly Mississippi Potash Inc East Mine). SNL-1 will be used to test hydraulic properties and to monitor groundwater levels of the Culebra Dolomite Member of the Permian Rustler Formation for WIPP.

SNL-1 was permitted by the New Mexico State Engineer as C-2953. 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-1

SNL-1 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-1 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; 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-1 was located to test Culebra hydraulic properties adjacent to the inferred upper Salado dissolution margin along the northeastern arm of Nash Draw as well as to confirm that brine from the Intrepid East mine tailings pile is infiltrating shallow formations (Sandia National Laboratories, 2003; Powers, 2002a, 2003a; Powers and others, 2003).

The drillhole is to (Sandia National Laboratories, 2003, p. 43; see also Appendix A):

1. Determine hydraulic heads immediately downgradient of the Mississippi East tailings pile;
2. Determine the transmissivity of the Rustler members where water may be entering the system;

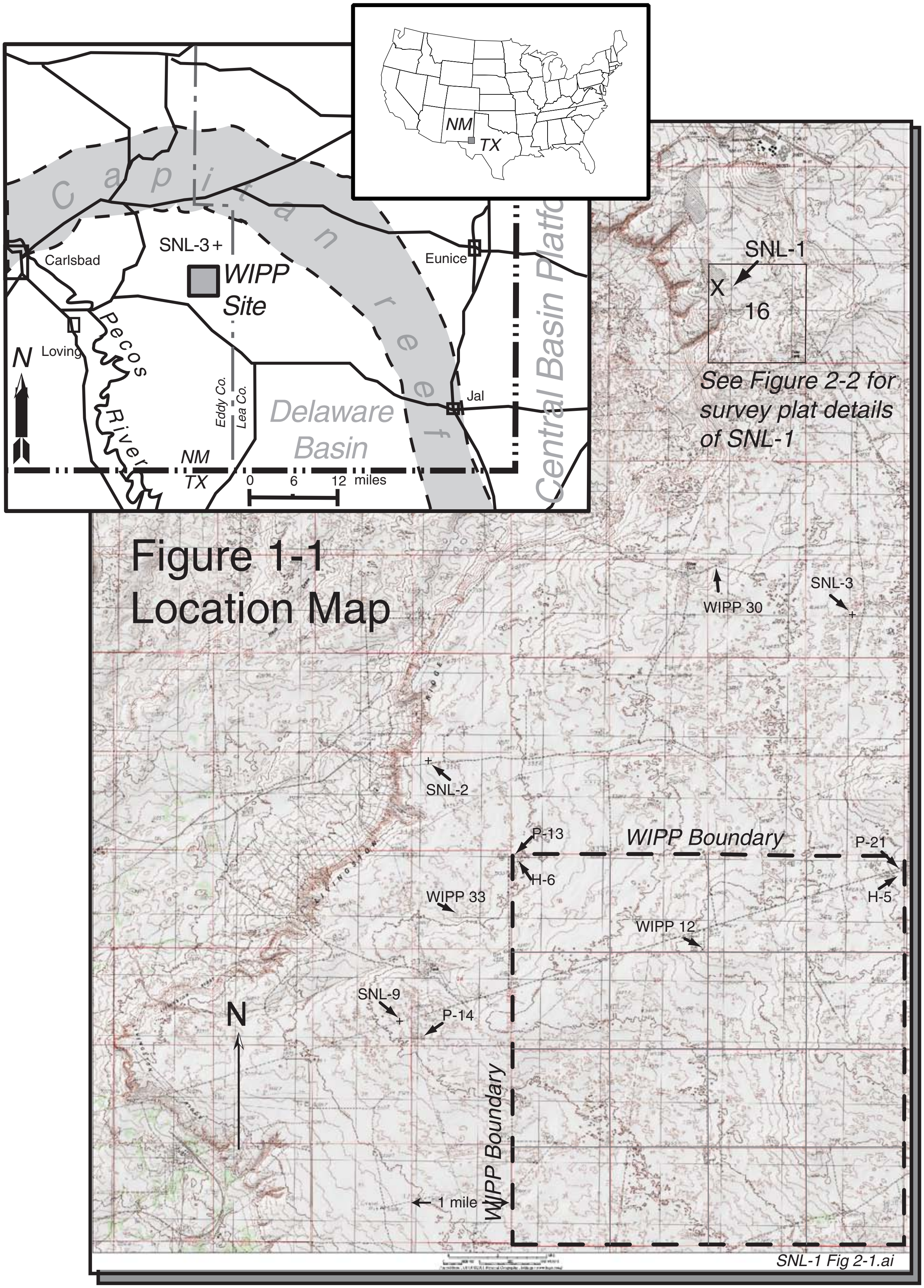


Figure 1-1
Location Map

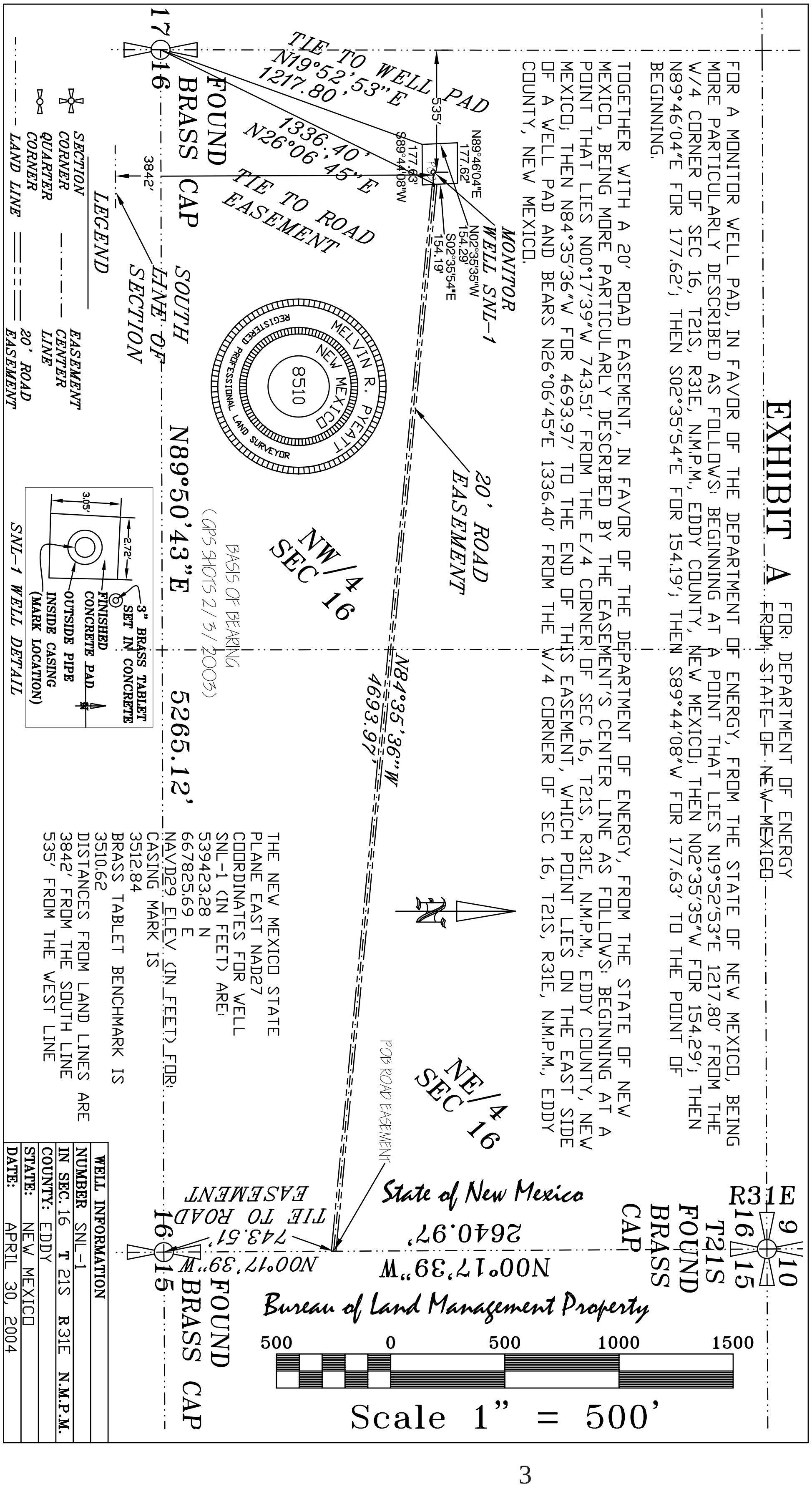


Figure 1-2
Survey Plat
for SNL-1

3. Determine if water-bearing horizons above the Rustler exist at this location; and
4. Determine, from water-quality analyses, if potash mining effluent is entering the Rustler members, and what the characteristics of that water are (e.g., solute concentrations, redox potential, etc.).

1.3 SNL-1 Drilling and Completion

The basic information about drilling and completion of SNL-1 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-1 was rotary drilled and cored to a total depth of 644 ft bgl (Fig. 1-3). After the drillhole encountered shallow brine while drilling with circulating air, fresh water was used with small amounts of surfactant (EZ Mud) added.

Core recovery ranged from excellent to poor (Appendix C), and this experience is common in these intervals (e.g., Powers, 2002b; Mercer and others, 1998).

In keeping with recent practice at WIPP, SNL-1 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-1 (Sandia National Laboratories, 2003).

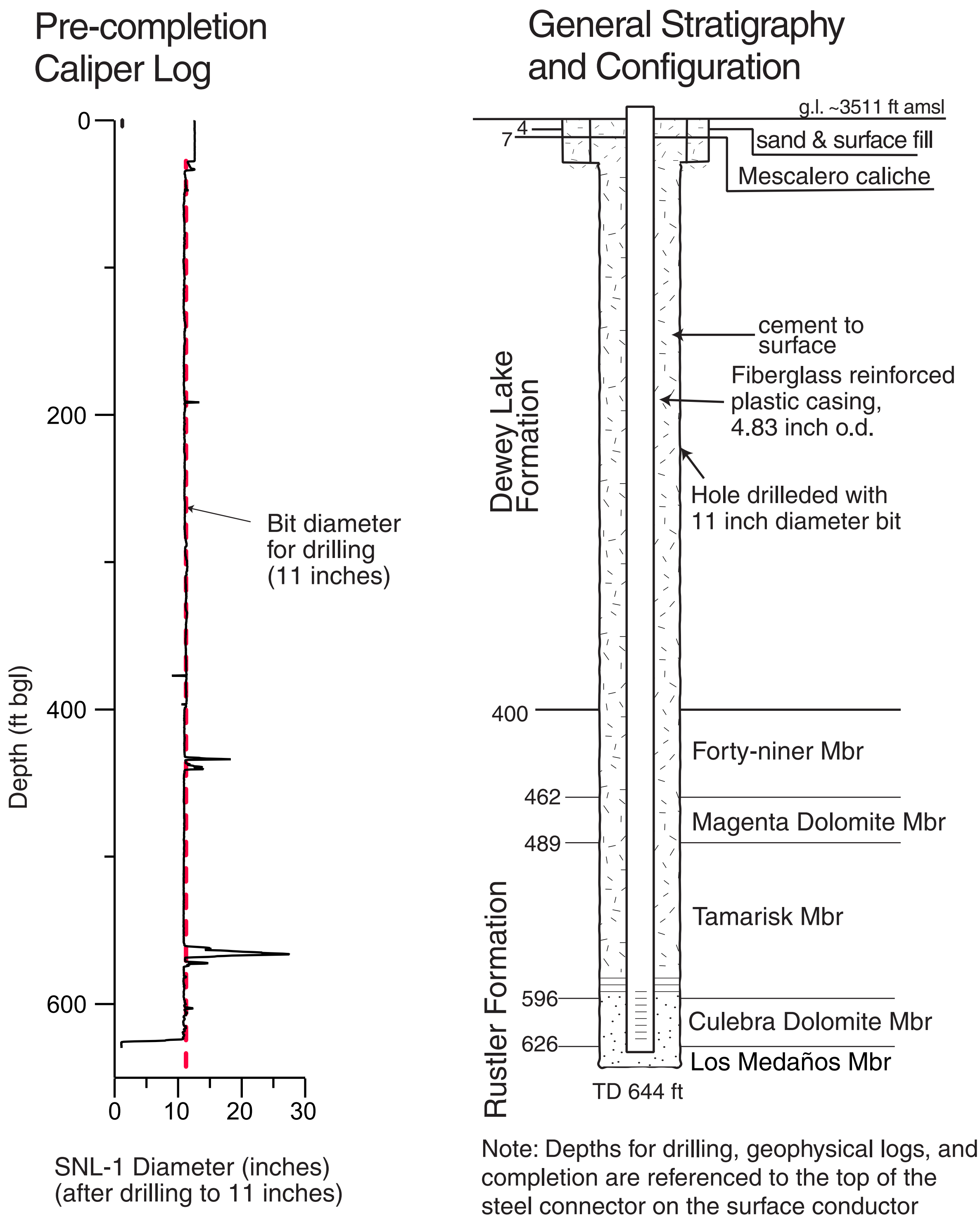
SNL-1 was completed with a single screened interval for monitoring and testing of only the Culebra Dolomite (Fig. 1-4). With a single completion interval, some of the difficulties associated with multiple completions can be avoided: expense of buying, placing, and maintaining packers; loss of water-level 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-1 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-1 (Fig. 1-4) (Appendices D and E). The drillhole did not penetrate the lower Rustler, so it did not need to be cemented (Fig. 1-4). The bottom of the Culebra screen interval was placed at 620 ft to remain above the claystone below the Culebra and avoid possible plugging of the lowermost slots by clay in the lower Culebra (Fig. 1-4). The top of the screen, at 593.25 ft, is just 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 584 ft is below the level of the mudstone in the Tamarisk to prevent connection to the Culebra. Bentonite (Hole Seal) was placed to 579 ft, and the annulus above the bentonite was cemented to the surface. The caliper log (Fig. 1-3) after the drillhole was drilled to 644 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. The annulus behind the casing was cemented through these 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-1 varied slightly during the course of drilling and completing the well and later monitoring of water levels. While drilling to an initial depth of 36 ft and monitoring shallow brine, the surface of the drilling pad was the reference point. A steel surface conductor casing was then cemented in place, and the top of the steel connector on the conductor casing (Fig. 1-6) was used as a common reference point for drilling; geophysical logging; and placing the screened interval, sand pack, bentonite seal, and cement. The top of the steel connector was estimated *at that time* to have an elevation of 3,512 ft amsl, based on the surveyed elevation (3,511.56 ft amsl)

Figure 1-3
SNL-1 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 ~3,511 ft amsl.

Table 1-1. Summary of Drilling and Well Completion Records for Hydrologic Drillhole SNL-1 (C-2953)

LOCATION: Northwest ¼, Section 16, Township 21 South (T21S), Range 31 East (R31E)

SURFACE COORDINATES: The well is located 3,842 ft from the south line (fsl) and 535 ft from the west line (fwl) of Section 16. The New Mexico State Plane (NAD 27) horizontal coordinates in feet are 539423.28 North, 667825.69 East (Fig. 1-2 shows the survey plat). Universal Transverse Mercator (UTM) horizontal coordinates (NAD27, Zone 13) in meters were calculated for SNL-1 using Corpscon for Windows (v. 5.11.08): 613780.92 East, 3594299.05 North. Figure 1-1 shows UTM coordinates on a 1,000-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. Depths are reported as below ground level (bgl), which is taken as 3,511 ft above mean sea level (amsl), the rounded value for the brass tablet benchmark (3,510.62 ft amsl) adjacent to the cement well pad. The primary datum for the completed well is 3,512.84 ft amsl (NAVD 29) for a mark on the top of the fiberglass reinforced plastic casing inside the protective well pipe. Figures 1-3 and 1-4 show the as-built configuration of SNL-1.

DRILLING RECORD:

Dates: Began drilling March 25, 2004; drillhole reached completion depth (644 ft) on April 6, 2004. Geophysical logging was conducted on April 6, 2004. Drillhole was prepared for casing, and was cased and cemented April 7, 2004. Rig was moved off the drillpad April 12, 2004. SNL-1 well development began April 15, 2004; the pump was removed on April 20, 2004.

Circulation Fluid: SNL-1 was drilled to 36 ft bgl with circulating air, discharging cuttings into a lined portable steel container. After brine was encountered at this depth, the hole was reamed to 30 ft using fresh water and Baroid EZ Mud® circulated in a portable mud pit, and the surface conductor casing was cemented in place. SNl-1 was then drilled and cored to total depth of 644 ft bgl using the same method. Cuttings were collected in portable steel containers. 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):
462.0–492.0 ft bgl: lower Forty-niner and Magenta Dolomite Members
548.0–636.5 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-1 (C-2953), continued.

Drillhole Record:

Size (inches)	From (ft bgl)	To (ft bgl)
18	0	30
11	30	644

Casing Record:

Outside diameter (inches)	Inside diameter (inches)	Weight/ft (pounds)	From (ft bgl)*	To (ft bgl)
13.38	12.72	48 steel	0	30
4.83	4.33	3.20 FRP** blank	-2.0	593.75
4.83	4.33	3.20 FRP screen	593.75	620.0
4.83	4.33	3.20 FRP blank	620.0	629.5

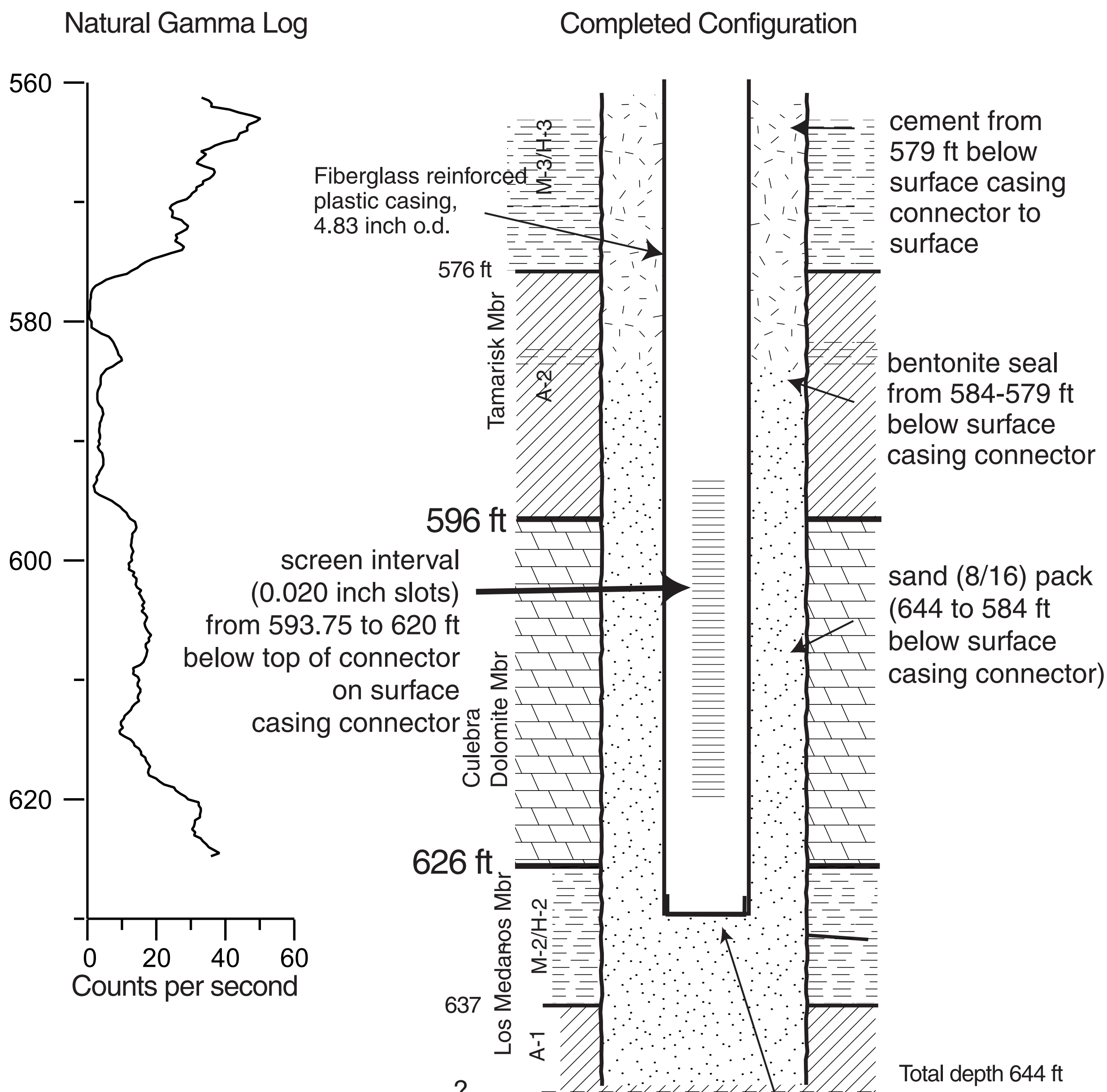
*Top of the casing connector is the reference for depth denoted below ground level (bgl). The FRP extends 2 ft (-2) above the connector casing.
**FRP: fiberglass reinforced plastic

Coring Record:

Core Run No.	Depth Interval (ft)		Interval (ft)		Recovered
	From	To	Cored	Recovered	%
1	462	492	30	30	100.00%
2	548	578	30	30	100.00%
3	578	601	23	22.6	98.26%
4	601	621.5	20.5	7.2	35.12%
5	621.5	636.5	15	14.5	96.67%
		Totals	118.5	104.3	88.02%

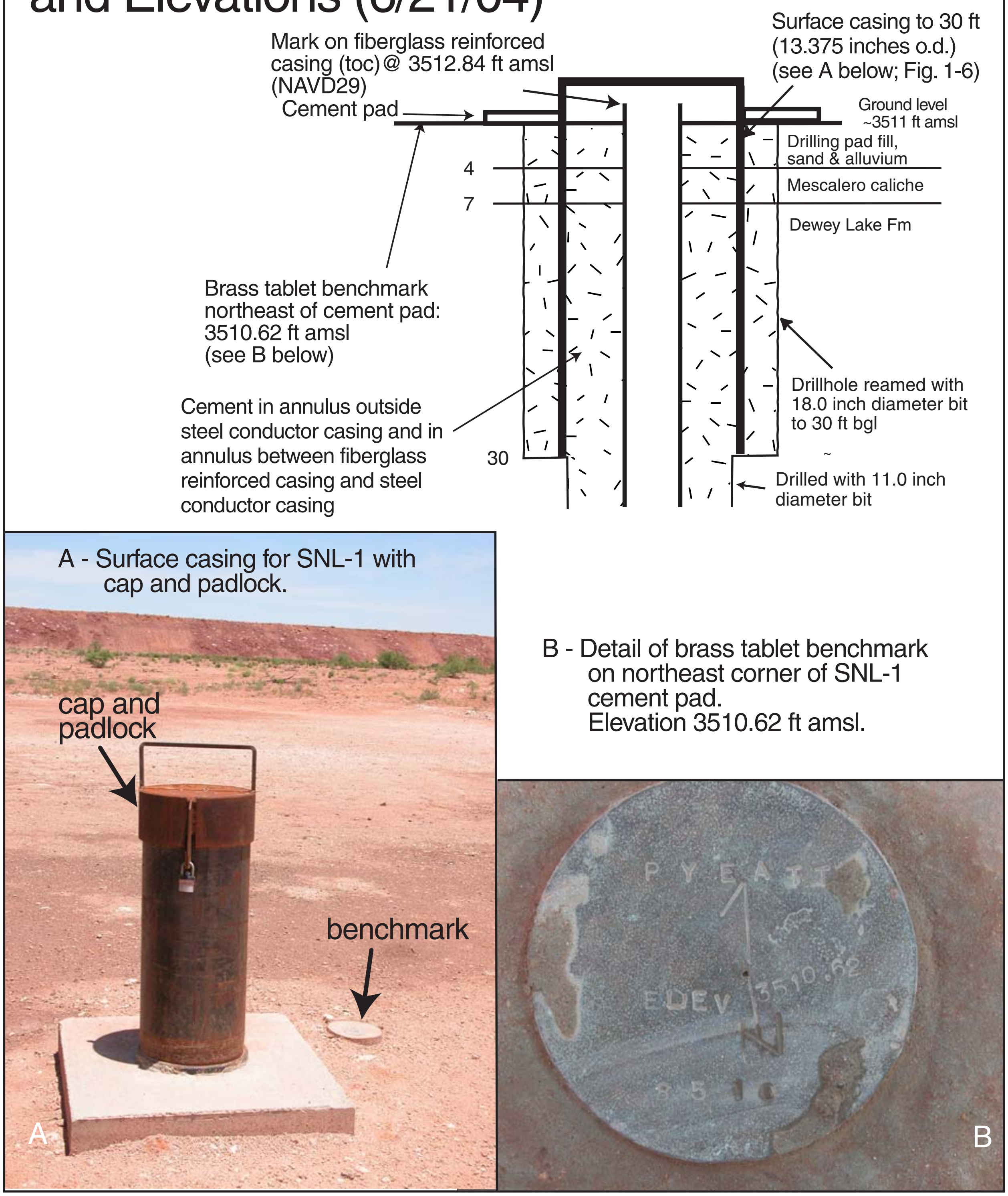
Note: Marked core depths (e.g., Appendix C) vary slightly within core interval depths partly due to differing recoveries and estimates of lost core intervals.

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



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 ~3,511 ft amsl.

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



of the drilling pad prior to drilling; *only geophysical logs reflect this information*. The benchmark placed at the drilling pad surface next to the completed well has an elevation of 3,510.62 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 ~3,511 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 (3,512.84 ft amsl) for monitoring water levels.

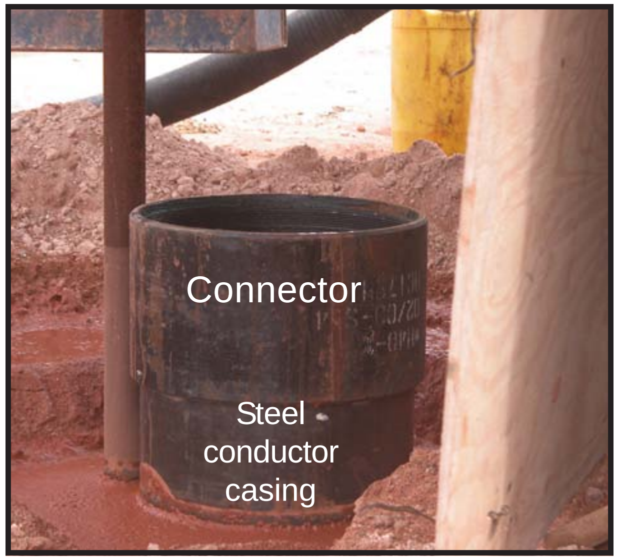


Figure 1-6 Reference Point for Drilling and Logging

1.4 Other Background

SNL-1 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 John Wood, 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 (brine and mud) were removed from SNL-1 and disposed of by Controlled Recovery, Inc., Hobbs, New Mexico, under New Mexico Discharge Permit DP-818 (Appendix E). 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-1 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 compilations are the Compliance Certification Application (CCA) submitted in 1996 by the DOE to the EPA (U.S. DOE, 1996) and the Compliance Recertification Application (RCA) submitted to the EPA in 2004 (U.S. DOE, 2004). 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-1.

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 been subject mainly to erosion during an extended period. Some basin tilting from mid- to late-Cenozoic 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-1

SNL-1 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. SNL-1 was drilled with water following encounter of shallow brine, and it is unknown if other units above the Rustler have saturated zones.

Geologic units encountered in SNL-1 are described from total depth to the surface, in the order in which they were deposited. 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 commonly resulted from depths and core markings through intervals of partial core recovery when compared to later geophysical logs. Decisions about placing screen intervals and annulus fillings were based on depths indicated by geophysical logs (Appendix D).

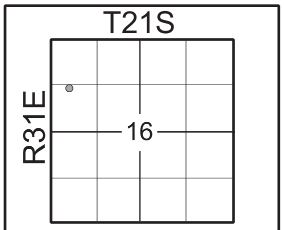
Note that the descriptions that follow use depths that correspond to core markings, with basic stratigraphic intervals provided by geophysical logs, as indicated.

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 400 ft bgl, and the Rustler thickness penetrated at SNL-1 is 244 ft.

Figure 2-1
Well Record SNL-1 (C-2953)

Company: Washington TRU Solutions LLC
Well: SNL-1 (C-2953)
Section: 16 Twp: T21S Rge: R31E
Location: 3842 ft from south line (fsl)
535 ft from west line (fwl)



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

Elevation
KB:
DF:
GL: 3511 ft amsl
(benchmark: 3510.62)

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: March 24, 2004
Completion date: April 7, 2004
Total depth (TD): 644 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:
620-593.75 ft

Geophysical Logs Date: April 6, 2004

Micro/Laterolog/Induction/SP:	0-630.5 ft
Gamma/Fluid:	0-630.5 ft
Caliper:	0-630.5 ft
Density/Neutron:	0-630.5 ft

Type fluid in hole: Water
Res mud: 0.42 ohm-m.
Res mud filtrate:
9.2 ohm-m.
Max. Rec. Temp.:
24.1°C

General Lithologic Symbols Used

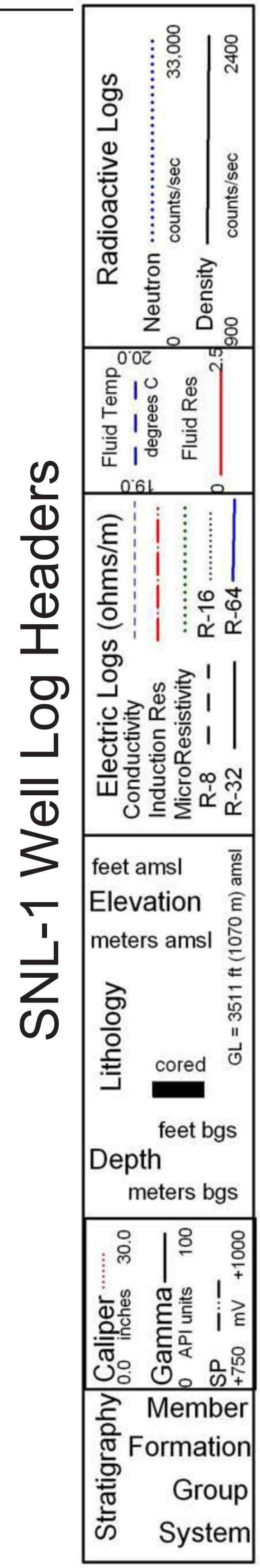
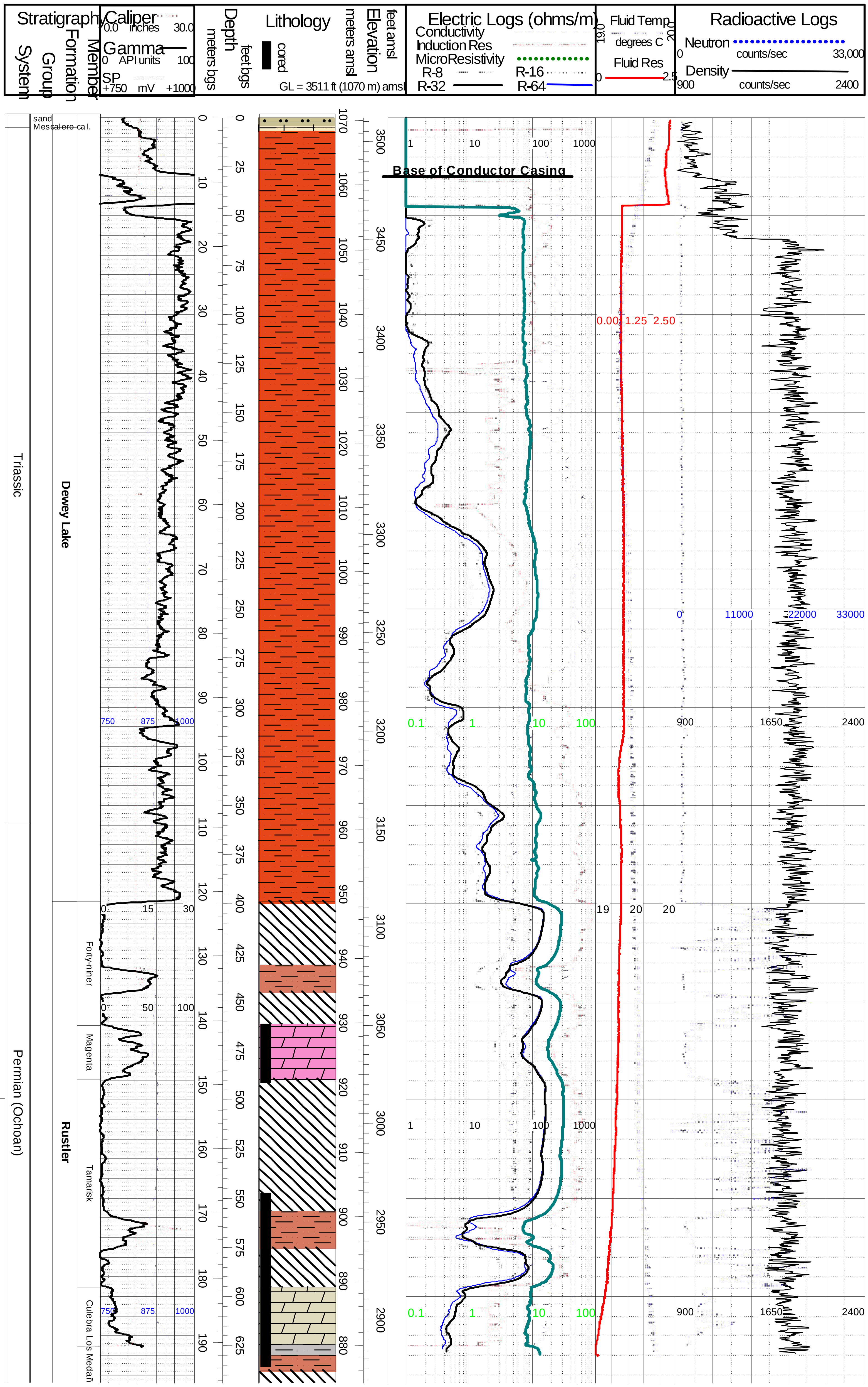


Figure 2-1 Log Title & Header page.ai



Stratigraphy
System
Group
Formation
Member
Caliper
0.0 inches 30.0
Gamma
0 API units 100
SP
+750 mV +1000
Depth
meters bgs
feet bgs
Lithology
cored
GL = 3511 ft (1070 m) amsl
Elevation
meters amsl
feet amsl
Electric Logs (ohms/m)
Conductivity
Induction Res
MicroResistivity
R-8
R-16
R-32
R-64
Fluid Temp
degrees C
Fluid Res
Radioactive Logs
Neutron
0 counts/sec 33,000
Density
900 counts/sec 2400
Base of Conductor Casing
sand
Mescalero cal.
Triassic
Permian (Ochoan)
Dewey Lake
Rustler
Forty-niner
Magenta
Tamarisk
Culebra
Los Medaños
0.00 1.25 2.50
0 11000 22000 33000
900 1650 2400
0.1 1 10 100
1 10 100 1000

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Table 2-1
Geology at Drillhole SNL-1

	System/ **Period/**Epoch	**Formation or unit**	**Member** *Informal units*	**Depth below surface (ft)**[1]
Cenozoic	Holocene	surface sand and alluvium		0 - 4 ft
	Pleistocene	Mescalero caliche		4 - 7 ft
	Miocene-Pleistocene	Gatuña		not present
Mesozoic	**Triassic**	Santa Rosa[2]		eroded
		Dewey Lake[3]		7 ft - 400 ft
Paleozoic	**Permian**	Rustler	Forty-niner *A-5* *M-4/H-4* *A-4*	400 ft - 462 ft *400 ft - 432 ft* *432 ft - 446 ft* *446 ft - 462 ft*
			Magenta Dolomite	462 ft - 489 ft
			Tamarisk *A-3* *M-3/H-3* *A-2*	489 ft - 596 ft *489 ft - 556 ft* *556 ft - 576 ft* *576 ft - 596 ft*
			Culebra Dolomite	596 ft - 624 ft
			Los Medaños[4] *M-2/H-2* *A-1*	624 ft - 644 ft (TD) *624 ft - 637 ft* *637 ft - 644 ft*

[1]Depths are based on measurements by geophysical logging; drilling and coring provided supplemental data to total depth (TD) of 644 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 3,511 ft amsl because it is a few inches above the elevation of the benchmark placed on the drilling pad adjacent to SNL-1. *Note that copies of the geophysical logs retained for records will show a reference elevation of 3,512 ft amsl based on the pre-drilling survey of the drilling pad.* 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 because of incomplete recovery and lesser precision using cuttings.

[2]The Santa Rosa Formation, part of the Dockum Group or undifferentiated Triassic, is apparently completely eroded at SNL-1; 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.

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). The clastic units below M-1/H-1 are cemented by halite in some areas, such as at SNL-2 (Powers and Richardson, 2004a), even though there is no discrete halite bed H-1 at that location. The halite margin for the Los Medaños below A-1 includes both bedded halite and halite cements (Powers, 2002a), called M-1/H-1 (Fig. 2-2) rather than being specific to the thinner zone designated M-1/H-1 in these earlier publications.

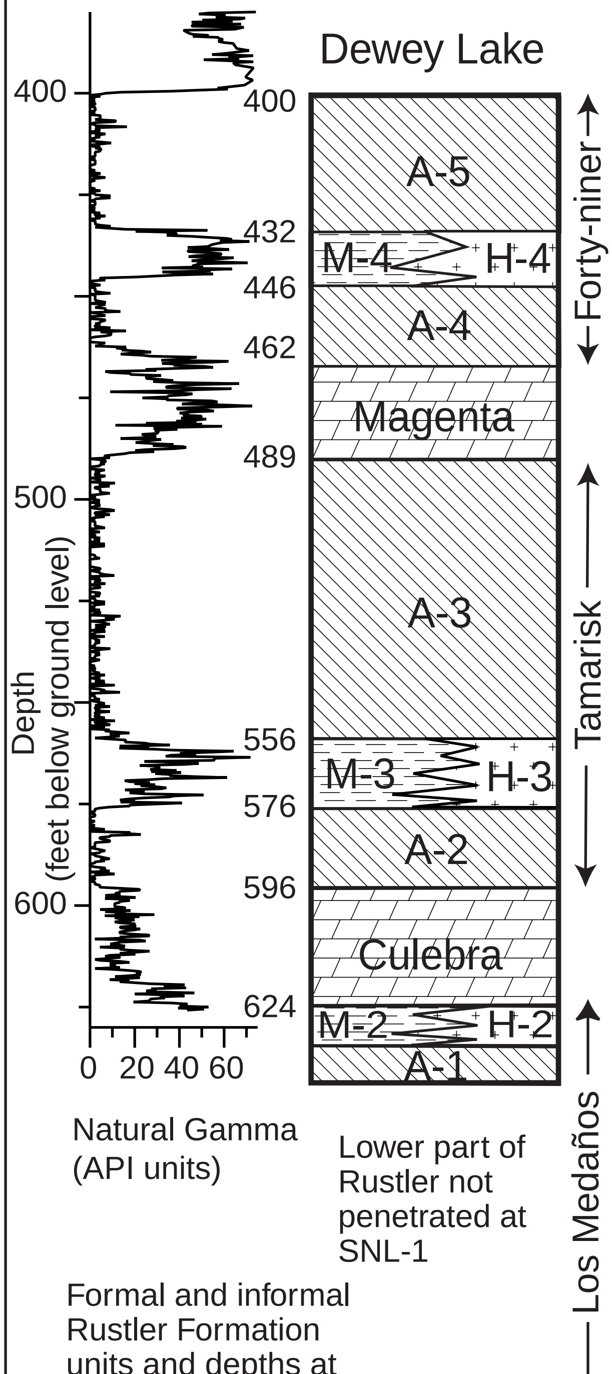
The upper part of the Los Medaños was cored (12.5 ft) and drilled (7.5 ft) in SNL-1, penetrating into A-1 but not deeper (Table 1-1).

The informal unit *anhydrite 1* (A-1; Fig. 2-2) was encountered from 644–637 ft bgl, based on drilling characteristics and limited cuttings. Fill in the drillhole prevented geophysical logging. The sedimentology of A-1 is not discussed because of the limitations of the cuttings.

The informal unit *mudstone-halite 2* (M-2/H-2; Fig. 2-2) was encountered from 637–624 ft bgl, based on drilling (base) and the natural gamma log (top) (Figs. 2-1, 2-2). The top of M-2 (contact between Los Medaños and Culebra) was marked at 625.5 ft based on drilling information available. Approximately 11–11.5 ft of core were recovered, representing most, if not all, of M-2.

The lower 4.5 ft of core is a reddish-brown (2.5YR5/4), calcareous siltstone with some gray mottling. The core has some gypsum in the lower 1 ft, near the contact with A-1. Core surface features

Figure 2-2
Rustler Units
at SNL-1



Formal and informal Rustler Formation units and depths at SNL-1 based on natural gamma log likely indicate smeared intraclast textures (Powers and Holt, 2000) that are thought to indicate syndepositional dissolution of halite.

From 632–626.9 ft, M-2 consists of interbedded dusky red (2.5YR3/2) to gray claystone and mudstone with zones of claystone and dolomite clasts ranging to about 1-inch diameter. Some zones include subhorizontal gypsum that fills separations. The interval is calcareous in the lower part and has probable smeared intraclast textures near the top.

The uppermost M-2 (626.9–625.5 ft) is a black to gray claystone with thin, subhorizontal gypsum along separations and a large clast or fragment of Culebra Dolomite (Fig. 2-3). The boundary between the Culebra and M-2 is commonly modestly deformed, with relief of inches or more. Here the boundary is more disturbed than normal, and the likely explanation is that M-2 has intruded into the basal Culebra as solution disrupted it. Nevertheless, the core material across the contact with the overlying Culebra Dolomite Member was not recovered as a continuous piece of core and interpretations are limited.

2.2.1.2 Culebra Dolomite Member

Based on the natural gamma log from SNL-1, the Culebra extends from 624–596.0 ft bgl, a thickness of 28 ft (Fig. 2-1). Based on drilling depths available at the time, the recovered Culebra core was marked from ~625.5–596.4 ft bgl (as used in information in Appendices C and G). Recovered Culebra core (Fig. 2-4) totals ~15.3 ft thick, indicating a core loss of ~13 ft from this unit. Based on the drilling activity and recovery of adjacent units, the core loss was attributed to the middle to lower Culebra (see Appendix C, sheets 6 and 7).

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 and the core and logs from SNL-12 (Powers and Richardson, 2004b). Significant core loss in the middle of the Culebra is common because of the porosity of that zone. The drill bit and drilling pipe dropped 2 ft from 617 ft to 619 ft in this zone where core recovery was poor, and drilling fluid was lost into the drillhole after the bit drop.

The dolomite recovered in core from SNL-1 ranged generally from light gray (2.5Y7/2) in the basal portions to pinkish gray (7.5YR7/2) in the upper part. Thin zones displayed wider color variations (Appendix C).

The basal hydrostratigraphic unit (CU-4) proposed for the Culebra by Holt (1997) is likely represented by the limited core recovered at the

Figure 2-3. Los Medaños to Culebra contact.

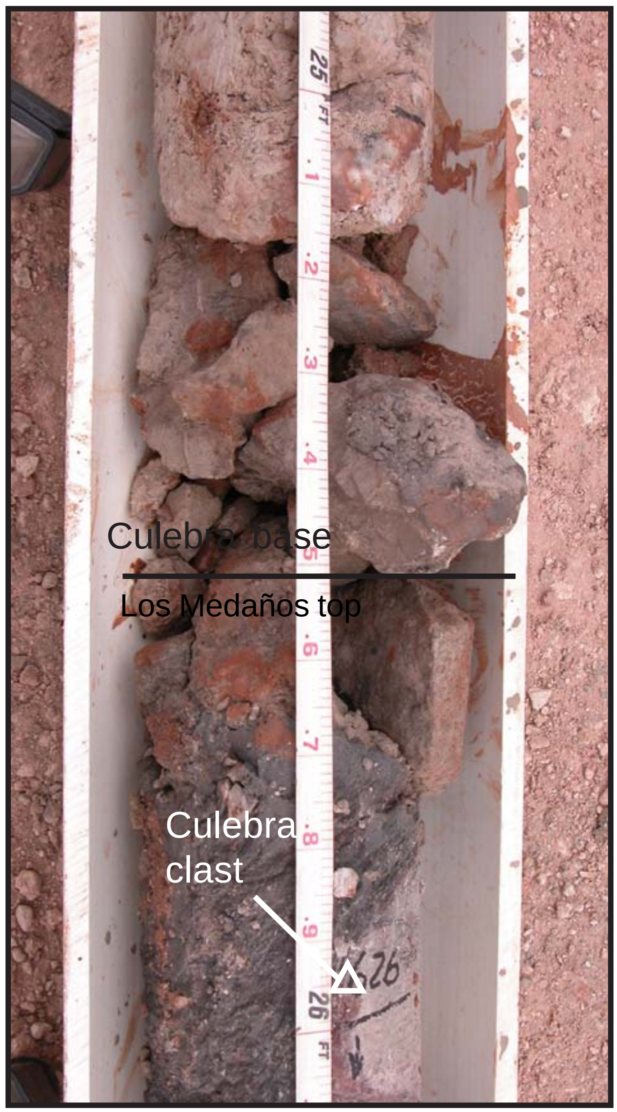
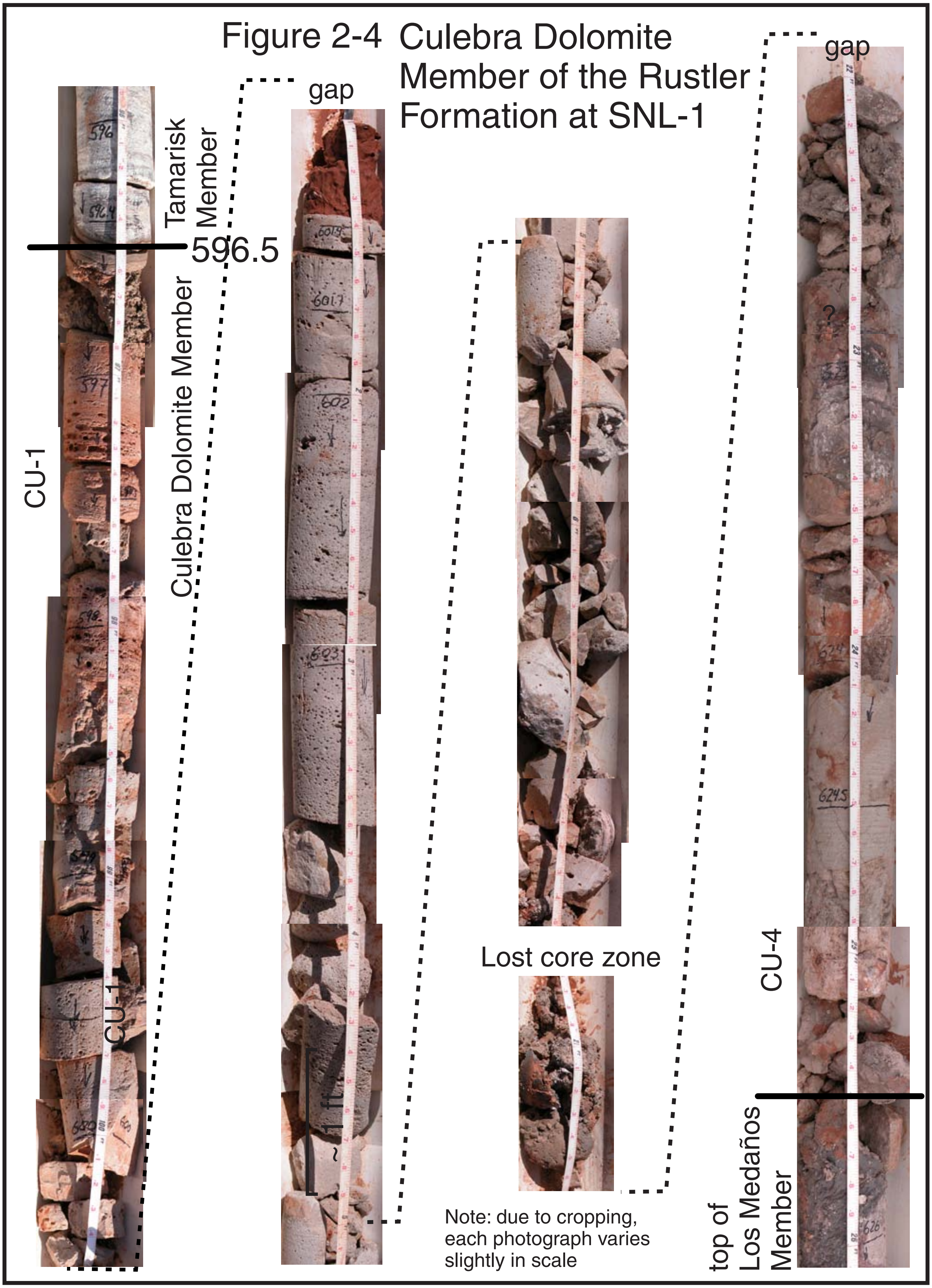


Figure 2-4 Culebra Dolomite Member of the Rustler Formation at SNL-1



base of the Culebra as well as the Culebra fragment in claystone a few inches below the apparent basal contact. The dolomite is fractured, and silt and dolomite fill the fractures.

There is no dolomite in the limited core in the depth interval equivalent to hydrostratigraphic unit CU-3 (Holt, 1997). The grayish-brown (2.5YR5/2; wet) silty claystone from 623.5–621 ft appears to be laminated, and it may be fill in vuggy to cavernous porosity, as indicated by the bit drop above this zone.

There is no core material from SNL-1 that is likely to represent the hydrostratigraphic unit CU-2.

The upper Culebra core from SNL-1 is characteristic of hydrostratigraphic unit CU-1, although it has been divided into two beds. From ~607.6–598.5 ft, the dolomite consists of thin zones of dark laminae separated by somewhat thicker (~1 inch) zones of light gray dolomite. Vugs are small (~0.065–0.25 inch), and this bed is less sandy and less porous than the overlying dolomite. Red (2.5YR4/6) mudstone at 601 ft is likely to be fill of cavernous porosity (Fig. 2-5). The uppermost bed of the Culebra (598.5–596.4 ft) is pinkish gray, sandy, and exhibits bedding ranging from low-angle cross-cutting beds to laminae with slight algal mounding at the upper contact. This bed also has vuggy porosity in zones parallel to bedding.

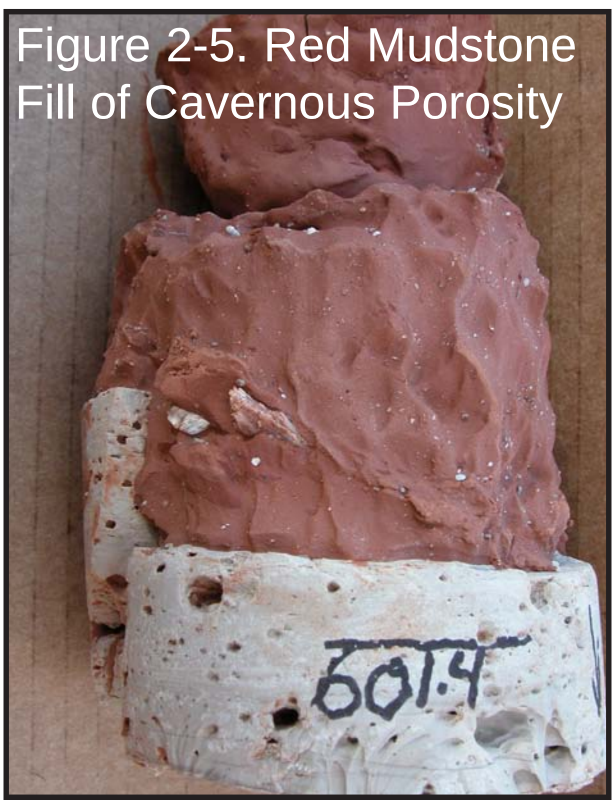


Figure 2-5. Red Mudstone Fill of Cavernous Porosity

The geophysical logs (Fig. 2-1) of the Culebra provide a few additional details of the unit, but they need to be interpreted with caution. For example, the caliper log does not show any evidence of cavernous porosity that might be expected with the bit drop from 617–619 ft. It seems probable that some of the porosity, if it was significant, was filled with cuttings from the circulating drilling fluid. The resistivity logs tend to show an upward increase through the Culebra that is consistent with lower porosity upward. The conductivity curve is markedly higher from ~598–604 ft, and this contrasts with little change in resistivity through the same zone. The conductivity may be responding to some cavernous porosity and fill (Fig. 2-5) through this zone, but it is not clear why the resistivity and conductivity do not correspond through the zone. The natural gamma log does not show zones in the upper part consistent with porosity with silt and clay fillings, but the lower part of the Culebra does show some increased natural gamma consistent with the clay retained during coring.

2.2.1.3 Tamarisk Member

The natural gamma log of SNL-1 shows that the Tamarisk occurs from 596–489 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-1 is located in the mudflat or M-3 facies of these beds. The basal 48.4 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 20 ft thick (596–576 ft) based on the geophysical logs. Core retained from the interval was marked from 596.4–576.3 ft, an interval thickness of 20.1 ft. A-2 is predominantly gray gypsum, with some anhydrite as well as thin claystone interbeds.

Above the contact with the Culebra (Fig. 2-4), A-2 is mainly gypsum and has subhorizontal beds with laminae of carbonate or organic material. The contact is sharp, with slight mounding due to algal growth. A high-angle fracture from 593.2–592 ft is filled with reddish-brown clay and clear gypsum crystals. Horizontal separations at 589.1 and 588.8 ft are also filled with mud.

Black (7.5YR2.5/) claystone from 583.6–582.9 ft includes thin subhorizontal gypsum; this claystone separates the lower and upper part of A-2 and is similar to claystones or argillaceous units observed elsewhere.

The upper part of A-2 is mixed coarse gypsum and anhydrite with some separations along bedding filled with gypsum. Thin laminae with some carbonate and probably algal zones are present in the upper ~1 ft, just below the overlying mudstone. The upper suface appears both eroded and corroded by some dissolution, probably at the time the overlying unit was being deposited. A stylolite is observable at 582 ft. A thin reddish claystone at 581.8 ft is similar material to fracture fill in the lower part of A-2.

The informal Tamarisk unit *mudstone-halite 3* (M-3/H-3; Fig. 2-2) is 17 ft thick (576–559 ft bgl) at SNL-1, based on the natural gamma. No halite (H-3) is present at SNL-1. The cored interval for M-3 is marked from 561.3–576.3 ft, which is about 2 ft less than the natural gamma. Core recovery was complete through the interval. The caliper log shows an enlarged diameter centered on the natural gamma signature. Assuming that the caliper indicates the position of M-3 because it was eroded more easily by circulating drilling fluid, the natural gamma was also responding to radioactive minerals in thin zones above and below M-3. Both sulfate units show carbonate and algal laminae adjacent to M-3, and the basal 1 ft of the overlying sulfate unit also includes some clay. These are the likely source of the additional gamma signature at SNL-1.

The basal contact with A-2 is sharp and erosional, and it appears also to show some dissolution of the underlying sulfate (Fig. 2-6). M-3 is dominantly reddish-brown mudstone with some gray zones and gray mottling. It is not as clearly color stratified as in other drillholes, such as SNL-3. In addition to some gypsum and gypsiferous beds, there are zones of gypsum clasts throughout M-3. Clear gypsum laths displace mudstone in some zones, including the uppermost gray siltstone (Fig. 2-7). The gypsum bed near the top is laminated, and it shows some deformation and invasion from the overlying gray siltstone. The gray siltstone at the top of M-3 has a sharp contact with the overlying sulfate and is inclined a few degrees from horizontal.

The informal unit *anhydrite 3* (A-3; Fig. 2-4) occurs from 559–489 ft bgl on geophysical logs, a thickness of 70 ft, which is thicker than at the WIPP site. The base of this unit as marked on core is at 561.3 ft. A well-defined contact between A-3 and the overlying Magenta is not included in the coring, although the core features and geophysical logs indicate that the bottom of core run #1 at 492 ft is at the top of A-3. The main part of A-3 was drilled.

The basal part of A-3 (13.3 ft) was cored, and this part of the unit is mainly gray anhydrite with gypsum zones lower in the cored interval. The basal zone includes probable dolomite and algal bedding. This zone displays some stylolites and some deformation or fracturing, and it includes clay. Beds become thicker and less distinct upward from the basal contact.

Most of A-3 was not cored, and the cuttings from drilling were not helpful. The geophysical logs for A-3 indicate some zonation within A-3 by resistivity and neutron abundance. A middle zone displays slightly lower resistivity and lower neutron that is consistent with some gypsum. A-3 displays low natural gamma and other log properties consistent with relatively uniform lithology.

The Tamarisk stratigraphy and thickness are consistent with other drillholes and shafts in the area (Holt and Powers, 1988) and do not suggest unusual conditions.

Figure 2-6. Eroded and Corroded Contact Between A-2 and M-3.

Figure 2-7. Gray Siltstone with Gypsum Laths at Top of M-3.

2.2.1.4 Magenta Dolomite Member

Based on geophysical logs, the Magenta at SNL-1 is 27 ft thick (489–462 ft). Core from the Magenta is marked from 492–464.8 ft, a thickness of about 27.2 ft (Fig. 2-8). A clear basal contact with the underlying A-3 is not shown in the core, although the geophysical logs and core features are consistent with the contact being at, or within inches of, the base of the core. Recovery was complete, with little fragmentation.

The Magenta consists of gypsiferous dolomite and gypsum, and is commonly olive (5Y5/3) to light olive gray (5Y6/2) in cores from SNL-1. Near the base, it is pale yellow (5Y8/3). 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-1, like outcrops and shaft exposures of the Magenta, is strong wavy to laminar bedding.

From the base at 492 to 486.8 ft, wavy, thin (<0.5 inch) beds and laminae in the Magenta increase amplitude upward, with small hemispheroidal algal growth (Fig. 2-8) near the top of this zone. From 486.8–480.5 ft, slightly wavy beds range from ~0.25-0.5 inches thick, include internal laminae, and show slight cross-cutting relationships. From 480.5–478.4 ft, small gypsum (or anhydrite) clasts are included. This zone also includes two high-angle fractures with fibrous gypsum filling. From 478.4–472 ft, the dolomite is laminar with small ripples and wavy bedding. The relief decreases upward, and there is an erosional surface at 473 ft. A nodular gypsum and anhydrite bed from 472–470.7 ft includes some carbonate laminae (Fig. 2-9). There are probably three episodes of nodule development in separate units. From 470.7–467 ft, the dolomite is laminar, with slight cross-cutting along bedding surfaces that exhibit up to 0.5 inch relief. Coarse sand-size grains are included. The uppermost Magenta is bedded to laminar, with gypsum grains or very tiny nodules in dolomite beds ~1–2 inches thick.

At 467 ft, there is a sharp contact. Nevertheless, there are carbonate beds within the basal part of the overlying anhydrite. As in many cores of this interval, the depositional environment fluctuated before sulfate-depositing environments strongly dominated.

The core of the Magenta appears to be most porous in the upper half of the member, above and below the nodular anhydrite and gypsum bed. The overall interval in core is from 477–467 ft (including nodular sulfate). The electrical logs indicate more porosity through the interval from 480–467 ft, corresponding to indications on the core. There are two high-angle gypsum-filled fractures at 480 ft.

The Magenta is typical in thickness, composition, and sedimentary features. The more porous zone in the upper Magenta is consistent in thickness and stratigraphic position with porous zones in many other Magenta cores, although the porosity may not be great. The Magenta is little fractured, especially compared, for example, to its condition at SNL-2, near Livingston Ridge.

2.2.1.5 Forty-niner Member

The Forty-niner at SNL-1 is 62 ft thick (462–400 ft), based on geophysical logs. A change in drilling rates was also noted at 400 ft, which is 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 462 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-1 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. 2-4), is white to gray, coarse to fine anhydrite and gypsum.

Figure 2-8 Magenta Dolomite Member of the Rustler Formation at SNL-1

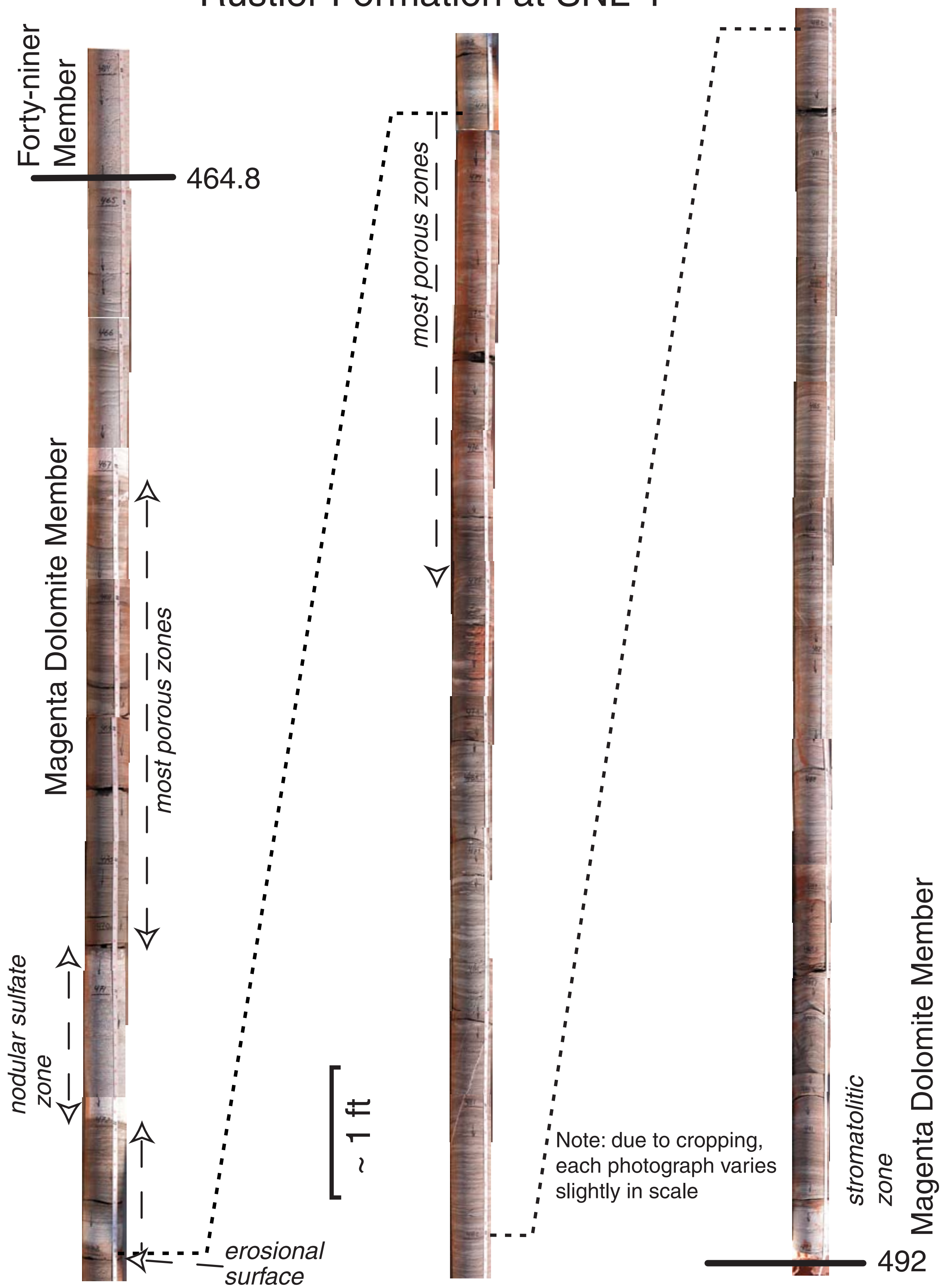


Figure 2-9 Composite Core Photographs of Nodular Sulfate in Upper Magenta

A-4 is 16 ft thick (462–446 ft), based on geophysical logs. The interval from drilling and coring is from 464.8–447 ft. The recovered core of A-4 from 464.8–462 ft includes thin carbonate laminae and beds as well as bedding-plane separations filled with gypsum. 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 464.8 ft (as marked on the core).

Mudstone-halite 4 (M-4/H-4; Fig. 2-4) is ~14 ft thick (446–432 ft), based on the natural gamma log. Cuttings returns and drilling rates indicating clastics from about 447–432 ft are consistent with the geophysical log. Cuttings from M-4 showed a lower light olive gray (5YN6/2; wet) silty claystone and a dark upper reddish-brown (5YR3/3: wet) claystone. No halite was observed in cuttings, nor was any indicated by geophysical log signatures.

The upper sulfate unit, *anhydrite-5* (A-5), is white to pinkish-gray (7.5YR6/2) gypsum and anhydrite ranging from coarse to fine and translucent crystals. It is 32 ft thick (432–400 ft bgl) at SNL-1.

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-1, the Dewey Lake is 393 ft thick (400–7 ft bgl) and is composed mainly of dark red (2.5YR3/6; wet) interbedded sandy siltstone, argillaceous siltstone, and fine–grained sandstone. Small gray reduction spots and zones are a common characteristic of the Dewey Lake and are recorded partially by the cuttings at SNL-1. The Dewey Lake is described on the basis of cuttings, drilling rates, and geophysical log characteristics.

Geophysical logs from SNL-1 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-12 (Powers and Richardson, 2004b).

Only the lower two of three general depositional regimes for the Dewey Lake Formation can be clearly distinguished on natural gamma logs of SNL-1. The base of the third may be preserved.

The interval from 400–320 ft bgl in SNL-1 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 at WIPP (Holt and Powers, 1988).

The interval from 320–40 ft bgl (280 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 ~320–310 ft. Near the center of the WIPP site, this interval is more than 300 ft thick; at C-2737 it was 260 ft thick (Powers, 2002b). South-southwest of SNL-1, 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 the interval from 52–44 ft, corresponding to very fine to medium-grained reddish-brown sand in cuttings. The sand grains are 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 natural gamma decreases above 40 ft to the top of the Dewey Lake at 7 ft. This 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. The top of the Dewey Lake appears to be weathered and infiltrated by carbonate from the overlying Mescalero caliche.

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 ~350 ft. Below 350 ft, cuttings included gypsum and were non-calcareous. Resistivity logs show an increase at ~340–350 ft, where gypsum was encountered. The resistivity also displays an increase from 215–260 ft that does not correspond to any observed change in the cuttings. The neutron flux and density logs are not helpful in defining the change in mineralogy at ~350 ft.

The boundary between carbonate (above) and sulfate (below) in the Dewey Lake at ~350 ft is stratigraphically low in the Dewey Lake compared to observations near the center of the WIPP site (e.g., Holt and Powers, 1988). This position is, however, similar to 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 ~350 ft, at or near the carbonate–sulfate boundary. The zone from ~260–215 ft also may have lower transmissivity compared to zones lower and higher.

2.2.3 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-1, the Mescalero is ~3 ft thick (7–4 ft). From cuttings, the Mescalero is a light red (2.5Y6/6), very calcareous, silty, argillaceous sandstone. Cuttings were of limited value. The unused mud pit on the drilling pad reveals evidence of pedogenic processes such as laminae development, but the Mescalero has clearly been disturbed by erosion and weathering. 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 shows features consistent with stage IV at SNL-1, but the profile is limited in thickness because of weathering and erosion.

2.2.4 Surficial Deposits

The surface materials consist of sand and alluvium on a sloping surface adjacent to an arroyo. There is no evidence of Berino soil. Construction fill is about 1 ft thick at the drillhole location.

3.0 PRELIMINARY HYDROLOGICAL DATA FOR SNL-1

SNL-1 was drilled specifically to monitor water levels and water quality from the Culebra Dolomite Member of the Rustler Formation and to serve as a location for observations during pumping tests. It was located near the tailings pile for the east mine of Intrepid Mining New Mexico LLC (formerly Mississippi Potash Incorporated) to check for infiltration of brine from the tailings pile.

3.1 Checks for Shallow Groundwater Above the Rustler Formation

A shallow saturated zone was encountered in the upper Dewey Lake. On March 25, 2004, cuttings from a depth of about 15 ft were damp and began to cake. At a depth of 36 ft, drilling was halted to verify the water was coming into the hole. After 5 minutes without returns of circulating air, water and wet cuttings were blown from the hole. The drilling pipe and bit were removed from the drillhole for 3 hours to observe water inflow (Fig. 3-1). The rate of water level rise decreased, and a polynomial function (Fig. 3-1) was fit to the data. A projection of the polynomial shows the decreasing rate of water level rise, but it should not be used as a basis for estimating the maximum water level for this zone.

Specific gravity from a sample was measured in the field at 1.21 grams/cubic centimeter (g/cc), indicating very high solutes or brine. Samples obtained by Sandia National Laboratories showed total dissolved solids of 330,000 milligrams/liter (Appendix E) (Table 3-1). Although the brine is dominated by sodium chloride, potassium is a very high component, further indicating the origin of the brine by infiltration from the adjacent tailings pile.

Following the encounter of brine, SNL-1 was drilled with circulating fresh water. Water inflow above the Rustler could not be observed. Potential differences in porosity of the Dewey Lake were discussed in Section 2.3.

3.2 Initial Results From the Magenta Dolomite

Fresh water was used to drill SNL-1 through the upper Rustler and Magenta. Water inflow through this interval could not be detected. On March 29, 2004, the fluid level before drilling began was at 39.5 ft, with the drillhole at 455 ft in the lower Forty-niner. On March 30, 2004, the fluid level before drilling was 25 ft, with the Magenta open to the drillhole. A modest volume of drilling fluid was lost to the drillhole each night, consistent with low porosity through the Magenta.

3.3 Initial Results From the Culebra Dolomite

As the Culebra was being cored at a depth of 617 ft, the core barrel and drilling pipe dropped 2 ft, and drilling fluid began to drop. Additional water (550 barrels total) was continuously added to complete drilling, with EZ Mud added to improve circulation.

After the well was completed, the Culebra was developed to prepare it for future testing and monitoring. On April 15, 2004, 38 barrels of water were used to flush the FRP casing at SNL-1 to clean out drilling fluid and mud left in the hole as the casing was placed. The screen interval was then jetted with 112 barrels of water at 200 psi. On April 16, 2004, a pump was installed in SNL-1, and the pump was run continuously for 6 hours, 40 minutes, at rates from 14 gpm to 16 gpm, producing clear water with a specific gravity of 1.024 g/cc by the end of pumping.

On April 20, 2004, SNL-1 was pumped for 3 hours at a rate of 13 gpm. The final specific gravity was 1.025 g/cc. Prior to pumping, the depth to water was 440.67 ft below the top of the FRP casing. The last depth to water measured, after 2 hours and 8 minutes of pumping, was 521.10 ft.

The water level for the Culebra in SNL-1 was measured May 12, 2004, at a depth of 441.15 ft, corresponding to an elevation of 3,071.69 ft amsl (Siegel, 2004). Recent water level measurements show little change (Table 3-2; Fig. 3-2).

Table 3-1
Solutes in Shallow Brine in SNL-1

Cation	mg/L
Sodium	91,000
Potassium	21,000
Calcium	540
Magnesium	4,500
Anion	**mg/L**
Chloride	190,000
Sulfate	15,000
Bicarbonate	290
Bromide	440

Figure 3-1
Shallow Water Depth at SNL-1
March 25, 2004

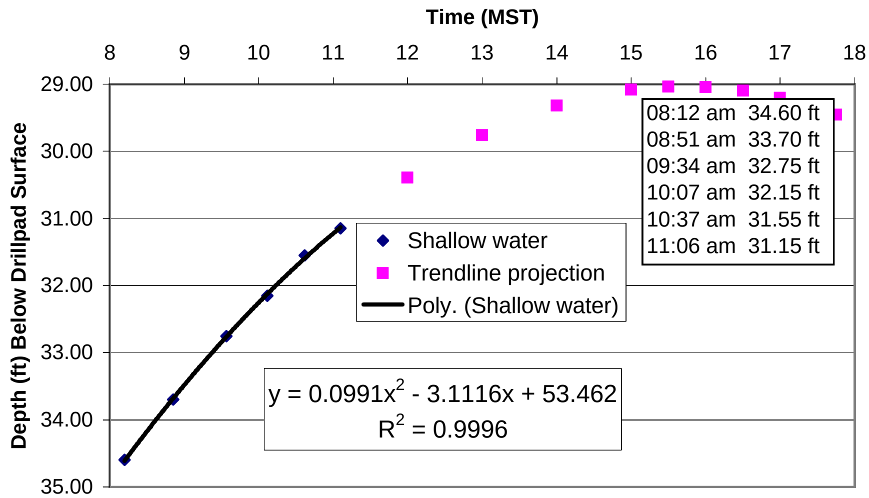
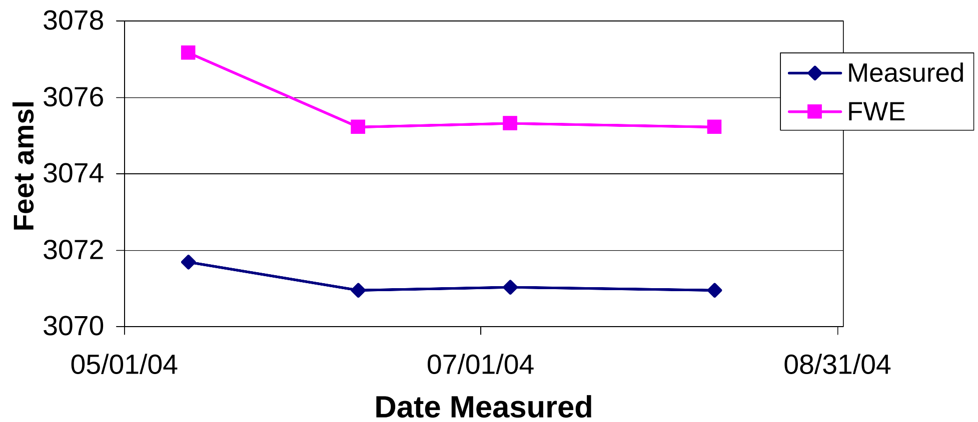


Table 3-2
Culebra Water Levels Measured In SNL-1

Date	Time (MDT)	Depth (ft) to water level	Water Elevation (ft amsl)	
			Measured	Fresh-water Equivalent
05/12/04	13:31	441.15	3071.69	3077.17
06/10/04	08:29	441.90	3070.94	3075.22
07/06/04	11:27	441.81	3071.03	3075.31
08/10/04	09:40	441.90	3070.94	3075.22

Source: Siegel, 2004.Measuring point reference for depth is 3512.84 ft amsl.

Figure 3-2
Culebra Water Elevation at SNL-1



4.0 SIGNIFICANCE/DISCUSSION

The materials used in completing SNL-1 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-1. Previous studies of thickness between the Culebra and Vaca Triste Sandstone Member of the Salado Formation (Powers, 2002a, 2003a; Powers and others, 2003) indicated that SNL-1 was located near the margin where upper Salado halite has been dissolved (Fig. 4-1). SNL-1 was also located near the margin of halite in M-1/H-1, the lower part of the Los Medaños.

The uppermost Los Medaños (M-2/H-2) does not include halite at SNL-1. This is consistent with previous halite margins for this unit (Powers, 2002a, 2003a) and a depositional origin for these facies.

Culebra core recovery was poor overall, with most of the recovered core attributed to the upper Culebra. This is a common problem, and not one that is specific to SNL-1. The core barrel and drill pipe drop from 617–619 ft is a significant indicator of cavernous porosity in the Culebra, and the gray argillaceous sediment recovered from the lower Culebra may indicate partial filling of cavernous porosity. Cores have not been investigated in detail to determine which processes have contributed to the development of cavernous porosity in the Culebra at SNL-1.

Along Livingston Ridge, the upper Salado dissolution margin is narrow, based on geophysical logs from oil wells across the margin. Near SNL-1, the thickness of the interval from Culebra to Vaca Triste (Fig. 4-1) is defined on data obtained from potash exploratory drillholes, and data are not as dense as at the Cabin Lake Field where SNL-2 was located (Fig. 1-1) along Livingston Ridge. A significant change in thickness along the Nash Draw escarpment (locally along the red dashed line in Fig. 4-1) near SNL-1 indicates that this escarpment also developed in response to upper Salado dissolution.

Data in Figure 4-1 reveal that the Culebra to Vaca Triste interval thickens north and east from this lower escarpment, and the thickeest areas are in an area east of a second escarpment (a green dashed line marks the general base of this escarpment on Figure 4-1). This second escarpment is held up by Triassic Santa Rosa Formation and well-developed Mescalero caliche. The rocks exposed along this second escarpment are not deformed as a monocline like Livingston Ridge or the escarpment west of, and near, SNL-1. It is undetermined at this time whether the thickness differences between escarpments are related to dissolution of the upper Salado or to changes in thickness of the lower Rustler due to halite presence and absence.

Drillhole data are sparse along the escarpment near SNL-1. The dissolution margin (Fig. 4-1) was placed along the escarpment because of the strong relationship between dissolution and the escarpment along Livingston Ridge. At SNL-1, the margin may not be as distinct, or there may be local penetrations past the escarpment leading to changes in porosity of units overlying the Salado, such as the Culebra.

The Magenta core showed some surface porosity and wetting in the upper part that is at the same zone where microresistivity decreased noticeably, suggesting a zone with relatively higher hydraulic conductivity compared to the rest of the Magenta. No data were obtained during drilling on any saturated zone within the Magenta.

Cuttings and resistivity changes suggest that the change in natural mineral cements of the Dewey Lake occurs ~350 ft bgl. This position is stratigraphically low compared to top of cement at the WIPP site center (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). North of WIPP, the boundary tends to be deeper stratigraphically, as found at SNL-1. Changes in resistivity suggest several porosity changes in the Dewey Lake, but the unit was drilled with water and saturated zones could not be distinguished.

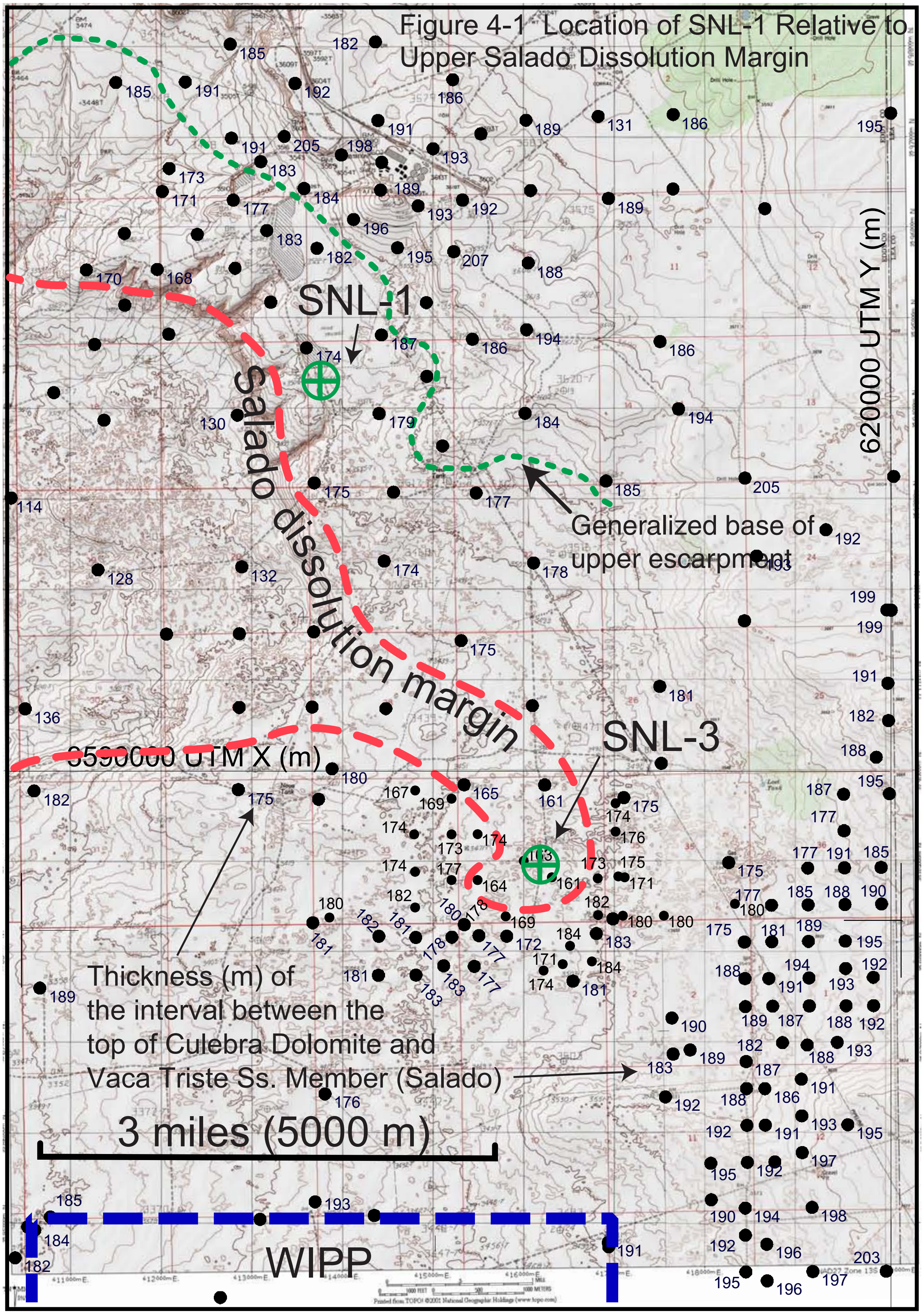


Figure 4-1 Location of SNL-1 Relative to Upper Salado Dissolution Margin
SNL-1
Salado dissolution margin
Generalized base of upper escarpment
620000 UTM Y (m)
590000 UTM X (m)
SNL-3
Thickness (m) of the interval between the top of Culebra Dolomite and Vaca Triste Ss. Member (Salado)
3 miles (5000 m)
WIPP

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Appendix A
Drillhole Objectives

The basic document providing the drillhole and operation objectives 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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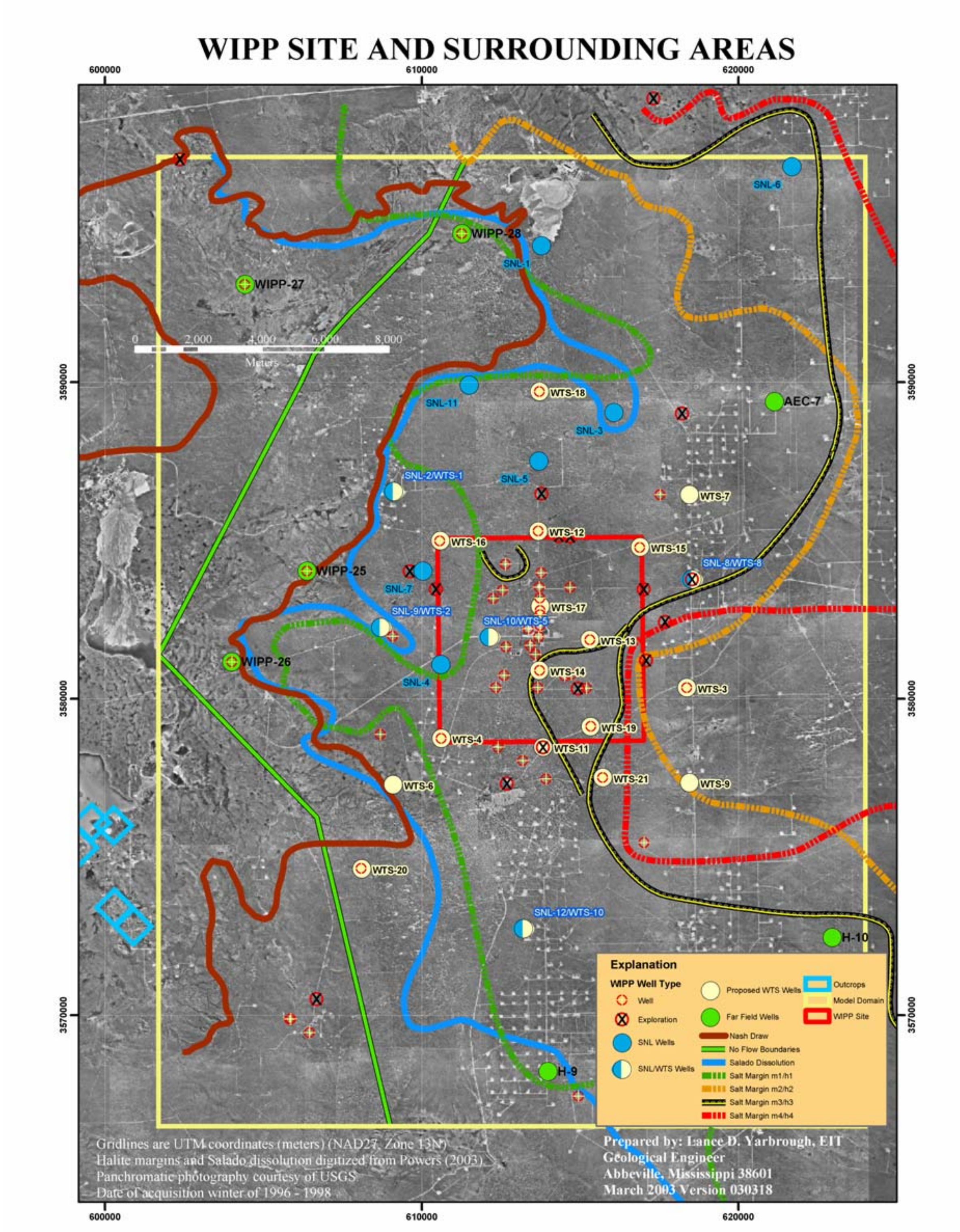
WIPP SITE AND SURROUNDING AREAS
600000
610000
620000
3590000
3580000
3570000
0 2,000 4,000 6,000 8,000
Meters
WIPP-28
WIPP-27
WIPP-25
WIPP-26
SNL-1
SNL-2/WTS-1
SNL-3
SNL-4
SNL-5
SNL-6
SNL-7
SNL-8/WTS-8
SNL-9/WTS-2
SNL-10/WTS-5
SNL-11
SNL-12/WTS-10
WTS-3
WTS-4
WTS-6
WTS-7
WTS-9
WTS-11
WTS-12
WTS-13
WTS-14
WTS-15
WTS-16
WTS-17
WTS-18
WTS-19
WTS-20
WTS-21
AEC-7
H-9
H-10
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…

SNL-1: Both Culebra and Magenta, and possibly Dewey Lake, wells will be drilled at the SNL-1 location, which is due south of the Mississippi East tailings pile (see Figure 8). These wells will be close enough to the tailings pile to provide a good measure of how much leakage of disposed water has increased heads in the Rustler. In addition, analyses of water samples collected from these wells should show whether or not the potash mining effluent is entering the Rustler members. This is also a location surrounded by potentially leaking potash holes (see Figure 7). The purposes of the SNL-1 wells are fourfold:

1. determine hydraulic heads immediately downgradient of the Mississippi East tailings pile;
2. determine the transmissivity of the Rustler members where water may be entering the system;
3. determine if water-bearing horizons above the Rustler exist at this location; and
4. determine, from water-quality analyses, if potash mining effluent is entering the Rustler members, and what the characteristics of that water are (e.g., solute concentrations, redox potential, etc.).

This information is critical in modeling the effects of the tailings pile on heads at the WIPP site.

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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-1	X		X					

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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-1	C, M?, DL?	M?		C, M	

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. The pumping well for the southern multipad test will prospectively be SNL-12/WTS-10, with observation wells as shown in Figure 20. Should SNL-12/WTS-10 not have the required pumping capacity, WTS-11 and WTS-6 (in that order) will be considered as fallback pumping locations.

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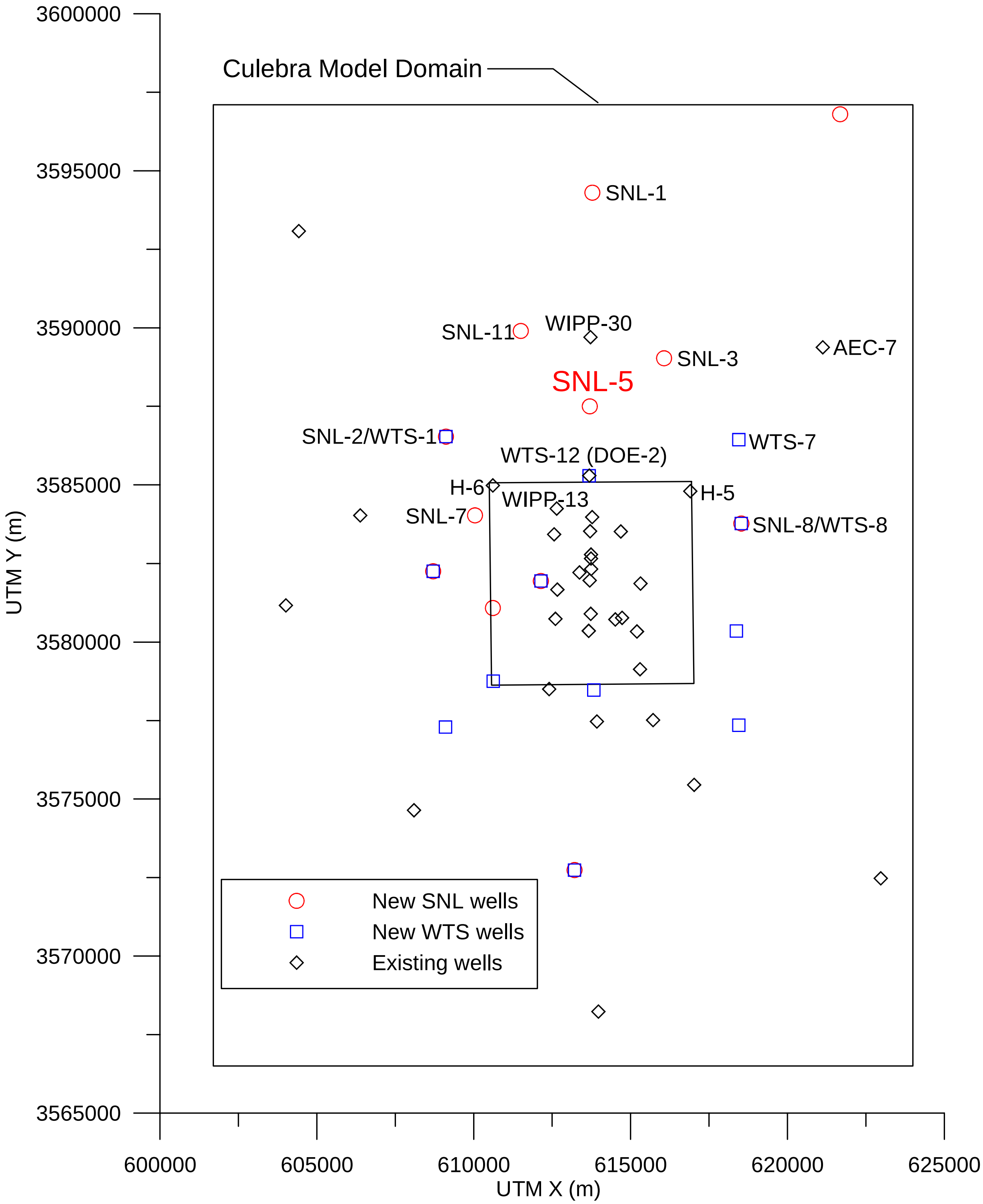

Figure 19. Pumping well and principal observation wells for northern multipad pumping test.

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5.3.3 Scanning Colloidal Borescope Logging

Direct measurement of the direction of groundwater flow is needed in the inferred Salado dissolution re-entrants, near the Mississippi East tailings pile, and on the edge of Nash Draw. Therefore, after SNL-1, 2, 3, 7, 9, and 11 have recovered from well development or pumping tests, the screened intervals of both the Culebra and Magenta (if present) wells will be logged using the scanning colloidal borescope. The scanning colloidal borescope images colloidal-size particles moving with the water through the wellbore, and tracks their motion to determine the direction and velocity of groundwater flow. In SNL-3 and 9, this will provide direct indications of whether the dissolution re-entrants serve as sources of fluid to the WIPP site, or as sinks for fluids coming from the east and north. In all cases, the information will be useful in flow model calibration.

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Table 4. Expectations and Contingent Actions for New Wells.

Well	Expectations	Possible Actions if Expectations Not Met
SNL-1	• high, similar heads in Culebra and Magenta • geochemical evidence of potash brine • moderate to high Culebra T	• replace WIPP-28 sooner than planned (FY05)

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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-1	670	550	??

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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.

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 using Central Standard time. For consistency, all time information in the abridged borehole history has been converted to Central Standard 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 CST (Central Standard Time) as recorded by WTWWS because they operate from Odessa, TX. Any additional notes included here (*in italics*) with times recorded in MST (Mountain Standard Time) at the site have been converted to CST. Geologic logs (main body of text) have times as MST, and times in the geologic logs commonly vary slightly from driller's log after allowing for the hour time difference.

3-23-04 Left Odessa, TX, at 07:00 CST (*see note above*) and drove rig and equipment to SNL-1 drillpad site. Brought field generator and trailer to site. Unloaded gravel and portable mud pits. Removed pipe and trailer from SNL-3 site to SNL-1. Set up rig. Left site at 18:00.

3-24-04 Arrived on site at 08:15. Held safety meeting. Rigged up air diverter. Barrett Moore provided welding on portable pit. Rigged up 11" bit. *Drilled through pad fill and upper caliche to 4'*, and set temporary 13 3/8" casing to 3' depth. Left site at 19:00.

3-25-04 Arrived on site at 07:05. Held safety meeting. Began drilling from 4' at 07:15. *Encountered moist cuttings beginning at 15'. Stopped at 16', circulated hole for 5 minutes. Reached 36' at 08:24. Stopped at 08:35 to observe hole. Blew water and cuttings from hole and shut down to observe water level rise.* Visited by Tom McGuire and Bill Jaco from Intrepid. *Water levels, measured from gasket on air diverter (about 33" above drillpad surface): 37.35' at 09:12; 36.45' at 09:51; 35.5' at 10:34; 34.9' at 11:07; 34.3' at 11:37; 33.9' at 12:06. Took 2 samples for WTS and 3 samples for SNL. Field measured specific gravity of 1.21 g/cc.* Removed air diverter and rigged up to drill 18" diameter hole with fresh water for suface conductor casing. Added Flowzan biopolymer to water for reaming. Reamed hole to 30' and circulated hole for 1 hour. Shut down and left site at 18:10.

3-26-04 Arrived on site at 07:00. Held safety meeting. Water level at 4 ft below ground surface at 07:15. On standby for EZ Mud delivery from Odessa. Added 4 gallons of EZ Mud (Baroid) to water and circulated hole from 08:30 to 09:00. Changed 18" bit to 11", cleaned out 6' of rat hole and circulated hole from 09:30 to 09:45. Ran 13 3/8" casing in hole. Ran tremmie pipe into hole. Rigged up to pump cement. Mixed 29 bags of Portland and pumped into hole. Cleaned up site and left at 11:30.

3-27-04 Arrived on site at 07:05. Held safety meeting. Primed mud pump. Tripped into hole and cleaned out about 6' of fill. Rigged up 11" bit and began to drill from 36' at 08:27 using circulating fresh water. Reached 309' at 17:10. Circulated hole until 17:30. Tripped out of hole, shut down, and left site at 18:00.

3-28-04 Arrived on site at 07:00. Held safety meeting. Measured water level at 49' below collar. Tripped into hole, and reamed tight areas. Began to drill 11" hole from 309' at 08:24 using circulating fresh water. Reached 455' at 17:10. Circulated on bottom of hole, and tripped out. Secured site and left for evening at 18:25.

3-29-04 Arrived on site 06:55. Held safety meeting. Measured fluid level at 39.5' below surface casing. Tripped into hole, and reamed tight zones on way in. Began drilling at 455' at 08:15; reached 462' and circulated hole from 08:45 to 09:15. *John Wood (DOWDCO) on site for coring.* Tripped out of hole; halted for lunch. Set up for coring and began tripping into hole at 12:00. Began coring from 462' at 13:15. *Lea Land arrived on site with additional roll-off for cuttings and mud.* Circulated at 492' at 16:00 and tripped out. Laid down core from 16:30 to 16:45; cut 30' and recovered 30'. *Powers determined bottom of core at or near base of Magenta Dolomite and recommended drilling from this point to next core point.* Core cleaned, marked, photographed, and boxed for move into secured trailer. Site secured at 18:50; departed for Carlsbad.

3-30-04 Arrived on site at 07:00. Held safety meeting. Measured water level at 25' below top of casing connector. *Finished describing core details from Magenta Dolomite.* Tripped into hole with 11" bit, reamed cored interval from 462 to 492' and began drilling to next coring point. Reached 548' at 16:45 and circulated hole. Prepared for coring next day. Secured site and left.

3-31-04 Arrived on site at 07:05. Held safety meeting. Measured water level at 39.5'. Started tripping in with core barrel at 07:20. Circulated hole. Began coring from 548' at 08:38. Reached 578' at 11:00. Circulated hole, and tripped out with core barrel. Laid down core at 12:00; recovered 30'. Tripped back into hole by 13:30. Worked on lift pump until 13:45. Began coring at 578' at 13:45. Completed coring at 601' at 15:35; circulated hole. Tripped out of hole and laid down core by 16:45. Cut 23' and recovered 22.6'. Assembled core barrel and shut down rig. Core was cleaned, marked, described, boxed, and removed to trailer. Secured site and left for evening at 17:45.

4-1-04 Arrived on site at 07:05. Held safety meeting. Measured static water level at 30' at 07:30. Tripped core barrel into hole and circulated on bottom from 08:20 to 08:40. Began coring from 601'; reached 621.5' at 09:20. Tool drop from 617-619'; lost circulation. Tripped out with core and laid core down from 10:00 to 10:08. Recovered 7.2' of 20.5' cored. Water level in hole at 179' at 10:30. Hauled water to support drilling. Started tripping in with core barrel at 11:30; shut down for lunch. Finished tripping in at 13:10 and began coring to 636.5'. No fluid returns to surface. Completed coring at 13:52 and tripped out with core. Laid down core; recovered 14.5' of 15' cored interval. Broke down core tool and loaded onto trailer. Continued to haul water for drilling and completing operations. *Additional frac tank delivered, inspected and approved by bargaining unit.* Water pump broken down. Secured site at 18:00 and left for evening.

4-2-04 *Fixed water pump and continued to haul water to fill frac tank. Secured site at 15:20 and left for weekend.*

4-5-04 Arrived on site from Odessa, TX, at 09:00. Held safety meeting. Measured static water level at 130'. Installed alternator and battery on generator. Tripped into hole from 10:10 to 11:10. On standby from 11:10 to 11:45 due to bad weather. Began reaming cored hole from 548 to 629' at 11:45. Reached 629' at 17:00. Circulated hole until 18:00, but cuttings would not clear out. Added 15 gal EZ Mud during drilling. Tripped out from 18:00 to 18:40. Secured site and driller left for Odessa, TX, to pick up more additive.

4-6-04 Driller arrived on site at 08:55 from Odessa, TX. Held safety meeting. Tripped into hole from 09:10 to 10:00. Fill at 614'. Waited until 11:05 for EZ Mud from Odessa. Mixed EZ mud (45 gallons) in pit. Began drilling at 11:20 and drilled extra depth to 644' to allow for settled cuttings. Reached 644' at 11:48. Circulated until 13:20 and tripped out. *Used 550 barrels of water during drilling (see WTWWS notes for 4/7/04).* Raymond Federwisch on site and ran geophysical logs from 14:13 until 17:27. Rick Beauheim on site to confer on completion of drillhole. *Set basic completion configuration from geophysical log results.* Secured site and left.

4-7-04 Arrived on site at 07:00. Held safety meeting. *Water level at 95' below surface.* Tripped into hole and tagged fill at 632'. Tripped out by 09:05. Ran tremmie pipe into hole by 10:30. Set up to run casing by 10:54. Ran casing into hole by 12:45 and broke for lunch. Rigged up grout pump from 13:10 to 14:15 and cut off excess casing 2' above surface. Worked on grout pump. Pumped sand into hole and tagged top at 584' beginning at 15:10. Pumped hole seal (5 bags) in hole; ended 15:45. Waited on cement. Pumped about 380 bags of cement into annulus and back to surface from 17:55 to 19:00. Tim Williams from New Mexico State Engineer on site during cement pumping.

4-12-04 WTWWS arrived on site at 10:00. Held safety meeting. Rigged down from 10:15 to 14:00. Installed 2' of 13 3/8" locking sleeve to protect casing and placed 3' x 3' cement pad around surface casing. Departed SNL-1 for Odessa at 15:00.

4-15-04 *Crew arrives at portacamp at 08:30. Left portacamp and arrived at SNL-1 at 09:00 for pressure jet development of well with target depth of 620'. Mast on rig found too short to bring pipe to top of well. Crew left site at 09:40 to get another rig. Mud not flushed from casing after drilling completed; will flush 40-50 barrels through casing to flush well. Set pipe to start casing flush by 14:15. Started flushing at 14:25; water is milky with lots of soapy bubbles. By 14:35, water was clear with no mud; occasional clay chunks flushed. Flushed 38 barrels of water by 14:43; water clean and clear. Pulled pipe to install jet tool. Started down hole with jet tool at 15:20. Set up by 16:05 to start jetting at 200 psi. First returns at 16:10 were very clear. Jet tool is set about 4' into sump. Jetting progressed with water much clearer than other wells. Completed jetting by 17:30; total 112 barrels used. Completed setting pump at 614.38' for pumping by 19:00.*

4-16-04 *Arrived at SNL-1 at 07:30. Set up for pumping. Starting pumping at 08:20 at 14 gpm; water light tan, silty. Flow rate was 16 gpm at 08:45; water tan and silty. Flow rate was 16 gpm at 09:00; water tan and silty. Flow rate was 15.5 gpm at 09:30; water much clearer. Flow rate was 16 gpm at 10:00; water was very slightly silty, tasted salty. Flow rate was 15.5 gpm at 10:30; water was clear, with fluid density of 1.023 g/cc. Flow rate was 15.5 gpm at 11:00. Flow rate was 15.5 gpm at 11:30; water was clear and fluid density was 1.024 g/cc. Flow rate was 15.5 gpm at 12:00; water was very clear. Flow rate was 15.2 gpm at 13:00; water was clear, and fluid density was 1.024 g/cc. Flow rate at 14:00 was 15 gpm; water was clear and fluid density was 1.024 g/cc. Flow rate was 15 gpm at 15:00; fluid density was 1.024 g/cc. Pump was turned off at 15:01.*

4-20-04 *Arrived at SNL-1 at 08:30. Depth to water 440.67'. Started pump at 09:00; bled air. Water at surface at 09:06; fluid density 1.025 g/cc and temperature at 19.9 degrees C. Flow rate*

13 gpm. Depth to water at 09:15 is 510.18'. Flow rate at 09:20 is 13 gpm, and water is cloudy. Flow rate at 09:30 is 13 gpm. Could not get depth to water. Water was clear, fluid density was 1.024 g/cc at 22 degrees C. Depth to water was 520' at 09:58. Flow rate was 13 gpm at 10:00; water was clear, with fluid density of 1.025 g/cc at 23 degrees C. Depth to water was 520.32' at 10:08. Flow rate was 13 gpm at 10:17 and depth to water was 520.22'. Flow rate was 13 gpm at 10:29; depth to water was 520.06', and fluid density was 1.025 g/cc at 25 degrees C. Flow rate was 13 gpm at 10:43; depth to water was 520.50'. Flow rate was 13 gpm at 11:08; depth to water was 521.1', with fluid density of 1.025 g/cc at 25 degrees C. Flow rate was 13 gpm at 11:30; fluid density was 1.025' at 23.4 degrees C. Pump was shut down at 12:00; water was clear, density stabilized, and flow rate consistent. Tank volume was 250+ barrels.

Top: Fiberglass reinforced plastic pipe at SNL-1 showing threaded ends at connections.

Above: Cuts (“screen”) with 0.020 inch width in fiberglass reinforced plastic pipe to be placed across the Culebra Dolomite Member.

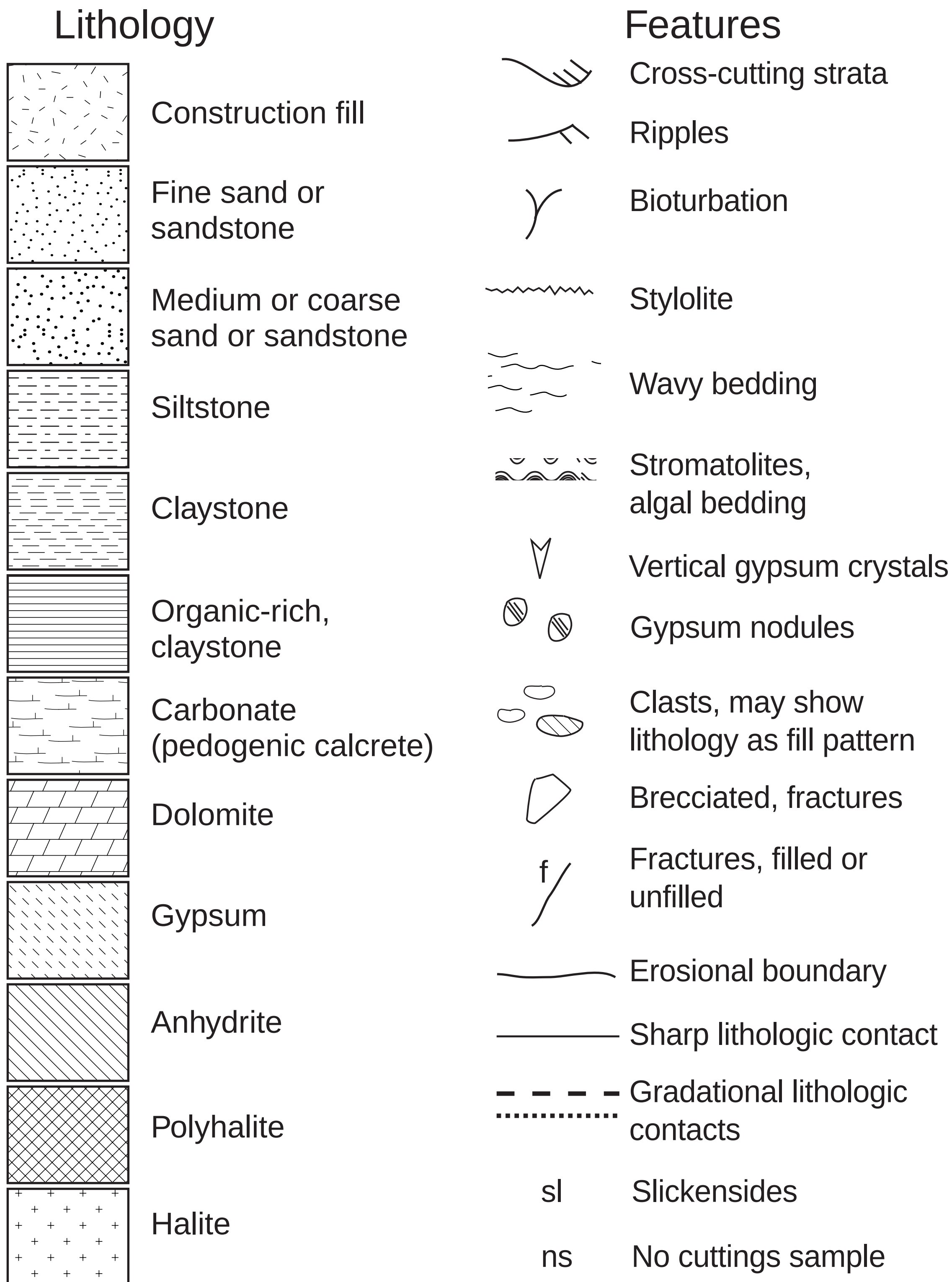
Right: Preparing threads at connections for permanent sealing.

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)



Symbols may be combined; not all symbols may be used

CORE LOG — Sheet 1 of 7

Hole ID: SNL-1	Location: 3842' fsl, 535' fwl (NW 1/4), section 16, T21S, R31E, Eddy County, NM

Drill Date: 3/25/04-4/6/04	Drill Method: Rotary	Drill Make/Model: Gardner-Denver 1500
Drill Crew: WTWWS; Ronnie Keith, Driller	Hole Diameter: 11 inches	Barrel Specs: 6" o.d.; 4" core
	Hole Depth:	Drill Fluid: air; water with polymer
	Hole Orient: vertical	Core Preserv: core boxes

Logged by: Dennis W. Powers, Ph.D.	Date: 3/24/04	Scale: 1" = 10'; variable

UTM Zone 13 (NAD27)	Northing	Easting	Elevation
Survey Coordinate: (m)	3594299.05	613780.92	3511 ft amsl

Comments: This drillhole was permitted by the State Engineer (New Mexico) as C-2953.

Run Number	Depth (feet)	% Recovered	RQD	Profile (Rock Type)	Description	Remarks
						Drilling with air in portable pit
N/A	0	N/A	N/A		Drilled 4' on 3/24/04 to set diverter for cuttings and air. 0-1': construction fill 1-2': surface sand 2-4': surface alluvium and caliche clasts	3/25/04 begin @ 4' @ 0615 MST 5' @ 0618 MST
		C-1 6'			4-7': Sandstone, silty, argillaceous, light red (2.5 YR6/6; slightly moist) sand is very fine, very calcareous; better developed as Mescalero caliche in lower part	
	10	C-2 10'				10' @ 0626 MST
		C-3 15'			7-400': Dewey Lake Formation; siltstone, sandy, argillaceous; interbedded with fine sandstone and claystone; calcareous to very calcareous to ~ 350'; gypsiferous from 350'; dark reddish brown or dark red (e.g., 2.5YR3/6, wet) with light gray or greenish gray spots and zones.	15' @ 0640 MST; moist cuttings @ 16', circulated hole for ~ 5 minutes - no water returned.
	20	C-4 20'				20' @ 0700 MST
		C-5 25'			25': moderately to slightly calcareous	25' @ 0712 MST
	30	C-x indicates cuttings sample number				
		C-6 35				35' @ 0722 MST 36' @ 0724 MST; observed fluid in hole; switched to fresh water with Flowzan, reamed 18" to 30'; end 3/25/04. 3/26/04 Water level @ 4'; set surface casing; water & EZ Mud. 3/27/04
	40	C-7 40'			40': Siltstone, argillaceous, sandy, dark red (2.5YR3/6, wet), includes caliche and chert pebbles, likely from above.	40' @ 0729 MST 45' @ 0735 MST
	50	C-8 50'			50': includes some fine to medium size, well rounded sandstone with few opaques; includes caliche and chert pebbles, likely from surface zones.	50' @ 0740 MST

Depth to water measured from bottom Kelley, ~ 2.75' above drillpad surface:

0812 MST	37.35'
0851 MST	36.45'
0934 MST	35.50'
1007 MST	34.90'
1037 MST	34.30'
1106 MST	33.90'

Took samples of water with bailer for SNL; field specific gravity 1.21 g/cc with hydrometer

Hole ID: SNL-1 | CORE LOG (cont. sheet) | Sheet 2 of 7

Logged by: Dennis W. Powers, Ph.D. | Date: 3/27/04

Run Number	Depth (ft)	% Recovered	RQD	Profile (Rock Type)	Note scale change / Description	Remarks
N/A	50	N/A	N/A		60': as above, caliche and chert pebbles diminish; little gray siltstone 65': more argillaceous than at 60'; small gray spots, some gray siltstone; moderately calcareous; interbedded fine sandstone 70': as above, continues to 220'.	55' @ 0751 MST
		C-9 60'				60' @ 0801 MST 65' @ 0811 MST
	70	C-10 70'				70' @ 0830 MST 75' @ 0834 MST
		C-11 80'				80' @ 0839 MST 85' @ 0846 MST
	90	C-12 90'				90' @ 0851 MST 95' @ 0858 MST
		C-13 100'				96' @ 0900 MST; add jt, begin 0912 100' @ 0915 MST 105' @ 0920 MST
	110	C-14 110'				110' @ 0925 MST 115' @ 0930 MST
		C-15 120'				120' @ 0936 MST 124.5' @ 0943 MST; add jt, begin 1000; mud foamy
	130	C-16 130'				130' @ 1007 MST 135' @ 1013 MST
		C-17 140'				140' @ 1018 MST 145' @ 1022 MST
	150	C-18 150'				150' @ 1028 MST 152' @ 1030 MST; add jt, begin 1108 155' @ 1110 MST
		C-19 160'				160' @ 1117 MST; stop 1119, tighten u-joint, begin 1120 165' @ 1126 mst
	170	C-20 170'				170' @ 1134 MST 175' @ 1141 MST
		C-21 180'				180' @ 1148 MST 183 @ 1151 MST, add jt, begin 1205 185' @ 1208 MST
	190	C-22 190'				190' @ 1214 MST 195' @ 1219 MST
		C-23 200'				200' @ 1224 MST 205' @ 1229 MST
	210	C-24 210'				210' @ 1234 MST

Hole ID: SNL-1 CORE LOG (cont. sheet) Sheet 3 of 7

Logged by: Dennis W. Powers, Ph.D. Date: 3/27/04-3/28/04

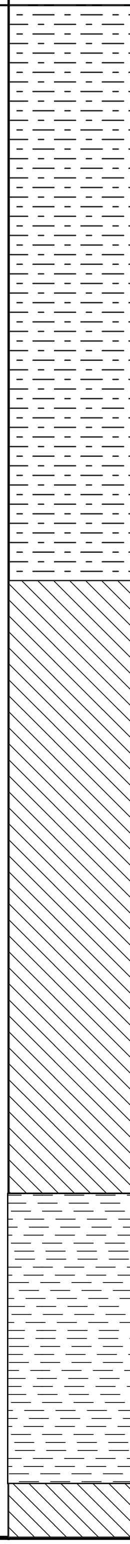
Run Number	Depth (ft)	% Recovered	RQD	Profile (Rock Type)	Description	Remarks
N/A	210	N/A	N/A			214' @ 1239 MST; add jt, begin 1255 215 @ 1256 MST
		C-25 220'			220': more gray than above	220' @ 1303 MST 225' @ 1311 MST
	230	C-26 230'			230': less gray, similar to 210'	230' @ 1320 MST 235' @ 1327 MST
		C-27 240'				240' @ 1335 MST 245' @ 1344 MST 246' @ 1346 MST; add jt, begin 1404
	250	C-28 250'				250' @ 1412 MST 255' @ 1420 MST
		C-29 260'				260' @ 1428 MST 265' @ 1438 MST
	270	C-30 270'				270' @ 1447 MST 275' @ 1456 MST 277' @ 1458 MST; add jt, begin 1512
		C-31 280'				280' @ 1518 MST 285' @ 1526 MST
	290	C-32 290'				290' @ 1533 MST 295' @ 1544 MST
		C-33 300'				300' @ 1554 MST 305' @ 1601 MST 309' @ 1606 MST; end 3/27/04 3/28/04 0615 MST water level 49' below connector on casing; begin 309' @ 0720
	310	C-34 310'				310' @ 0722 MST 315' @ 0733 MST
		C-35 320'				320' @ 0744 MST 325' @ 0753 MST
	330	C-36 330'				330' @ 0804 MST 335' @ 0815 MST
		C-37 340'				340' @ 0822 MST 341' @ 0825 MST; circulate hole, add jt, begin 0844 MST 345' @ 0850 MST
	350	C-38 350'			350-400': Includes flakes of gypsum; not calcareous	350' @ 0859 MST 355' @ 0912 MST
		C-39 360'				360' @ 0928 MST 365' @ 0942 MST
	370	C-40 370'				370' @ 0956 MST

Hole ID: SNL-1 | CORE LOG (cont. sheet) | Sheet 4 of 7

Logged by: Dennis W. Powers, Ph.D. | Date: 3/28/04

Run Number	Depth (ft)	% Recovered	RQD	Description (Note scale change)	Remarks
N/A	370	N/A	N/A		371' @ 1012 MST; add jt, begin 1017
	380	C-41 380'		380': as above	380' @ 1033 MST
					385' @ 1045 MST
	390	C-42 390'			390' @ 1058 MST
					395' @ 1111 MST
	400	C-43 400'		base of Dewey Lake Formation 400': Harder drilling; gypsum in cuttings @ 402 ft Top of Rustler Formation, Forty-niner Member	400' @ 1122 MST
					404' @ 1139 MST add jt, begin 1214
		C-44 405'		400-437': Gypsum and anhydrite, white to pinkish gray (7.5YR6/2); generally fine to medium crystalline, translucent to opaque	
	410	C-45 410'			410' @ 1241 MST
					415' @ 1301 MST
	420	C-46 420'		A-5	420' @ 1323 MST
					425' @ 1345 MST
	430	C-47 430'		Drilling changes at 432', 435' and 437'.	430' @ 1408 MST
					435' @ 1436 MST 436' @ 1438 MST, add jt, begin 1455
	440	C-48 440'		437-447': Claystone, silty, dark reddish brown (5YR3/3; wet) in upper part, light olive gray (5Y6/2; wet) below about 444'.	440' @ 1504 MST
				M-4	445' @ 1515 MST
		C-49 446'			
	450	C-50 450'		A-4	450' @ 1540 MST

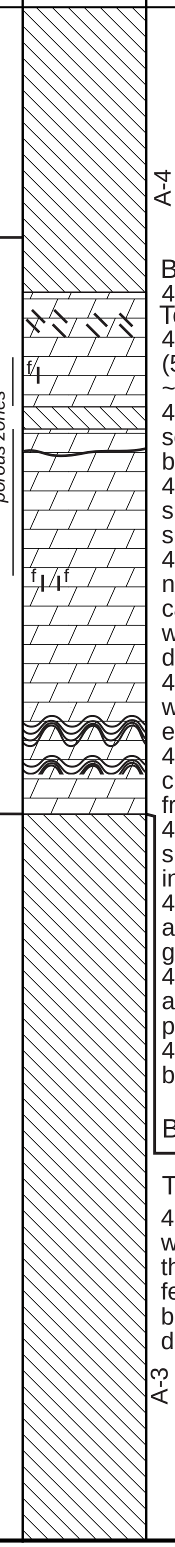
Profile (Rock Type):



Hole ID: SNL-1 | CORE LOG (cont. sheet) | Sheet 5 of 7

Logged by: Dennis W. Powers, Ph.D. | Date: 3/28/04-3/30/04

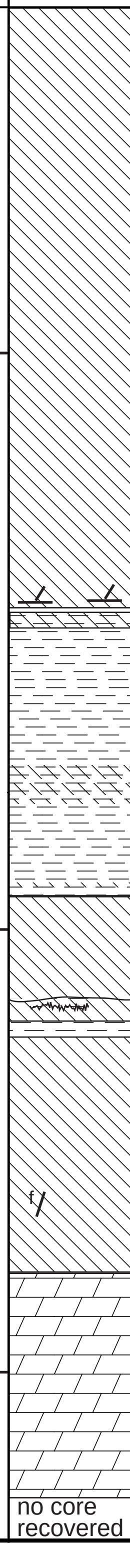
Run Number	Depth (ft)	% Recovered	RQD	Profile (Rock Type)	Description	Remarks
N/A	450–462'	N/A	N/A	A-4		455' @ 1605 MST; end drilling 3/28/04 3/29/04 0612 MST fluid level 39.5' below collar on conductor casing; circulate, drill to 462', core to 492'.
	460	C-51 460'				
1	462'–492'	Cut 30'; recovered 30'	0.8' in segments < 4" long (RQD = 97.33)	porous zones	Base of Forty-niner Member 464.8' Top of Magenta Dolomite Member 464.8-492': Dolomite, gypsiferous, generally olive (5Y5/3) to light olive gray (5Y6/2); more porous from ~467-470.7' and 472-480' 464.8-467: Gypsum and dolomite; bedded, laminar; some gypsum grains or very tiny nodules in carbonate beds ~ 1-2" thick 467-470.7': Dolomite, laminar, with slight cross-cutting surfaces; white & dark grains to ~0.08"; relief on surface to 0.5 inch 470.7-472: Gypsum and anhydrite, white to gray; nodular, with size increasing upward; some laminae of carbonate and organics; subhorizontal separations with gypsum; probably three episodes of nodule development 472-478.4': Dolomite, laminar, with small ripples and wavy bedding, relief ~ 0.25", decreasing upward; erosional surface @ 473' 478.4-480.5': Dolomite, with gypsum or anhydrite clasts and dolomite intraclasts; 2 high angle (~85°) fractures with gypsum fibers. 480.5-486.8': Dolomite, thin bedded, slightly wavy, slight cross cutting, beds ~ 0.25-0.5" thick, with internal laminae 486.8-490.5': Dolomite, laminated, with high amplitude bedding indicating algal bedding and growth; small hemispheroidal head 490-490.5' 490.5-491.7': Dolomite, thin beds, general < 0.5", low amplitude relief to wavy beds; some organic content, possibly algal mat. 491.7-492: Dolomite, pale yellow (5Y8/3); thicker bedding with some relief, gypsum at base Base of Magenta Dolomite Member 492'	end 3/29/04 @ 492' 3/30/04 0635 MST water level 25' below connector on conductor casing; ream, drill from 492'
	492'–530'	C-52 500' C-53 510' C-54 520' C-55 525' C-56 530'		A-3	Top of Tamarisk Member 492-561.3': Anhydrite, gray, fine to coarse crystals, with gypsum zones in lower part; thin laminae and thin beds from 561.3- ~554', more thickly bedded with fewer laminae 554-548'; probable dolomite and algal bedding 561.3-559.8'; possible stylolites and disruption in lower 1-2'.	500' @ 1054 MST 505' @ 1118 MST 510' @ 1138 MST 530' @ 1350 MST; add it



Hole ID: SNL-1 | CORE LOG (cont. sheet) | Sheet 6 of 7

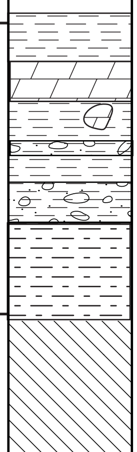
Logged by: Dennis W. Powers, Ph.D. | Date: 3/30/04-4/1/04

Run Number	Depth (ft)	% Recovered	RQD	Profile (Rock Type)	Description	Remarks
N/A	530–548	N/A; C-57 540'	N/A	A-3		535' @ 1428 MST; 540' @ 1454 MST; 545' @ 1530 MST
2	548'–578'	Cut 30'; recovered 30'	All segments > 4" long (RQD = 100)	A-3; M-3/H-3	548-561.3': Anhydrite, gray, fine to coarse crystals, with gypsum zones in lower part; thin laminae and thin beds from 561.3-~554', more thickly bedded with fewer laminae 554-548'; probable dolomite and algal bedding 561.3-559.8'; also included clay and silt, as well as possible stylolites and disruption in lower 1-2'. 561.3-562.4': Gypsum, gray, fine to coarse, bedded; some gray siltstone interbeds; siltstone at top with gypsum lath crystals, mostly subhorizontal. 562.4-569.8': Mudstone, dark reddish brown, some gray mottling, gray at top; thin bedding, some gypsum clasts; upper 2' includes displacive gypsum laths. 569.8-573': Gypsum, white, some interbedded mud at base; bedded to laminar. 573-574.8': Claystone, dark reddish brown; some gypsum clasts. 574.8-575.2': Gypsum, white. 575.2-575.9': Mudstone, reddish brown, some gray; gypsum clasts and displacive gypsum crystals. 575.9-576.1': Gypsum, white, granular. 576.1-576.3': Mudstone, reddish brown, and gypsum conglomerate, on erosional basal surface.	548' @ 1545 MST; end drilling 3/30/04 Static water 34.6' below surface @ 0620 MST 3/31/04; begin coring at 548'
	578'–601'	Cut 23'; recovered 22.6'	2.8 ft in segments < 4" long (RQD = 98.3)	A-2	576.3-588': Gypsum and anhydrite, gray, fine to coarse, bedded; some subhorizontal gypsum-filled separations that are hard to distinguish. From 576.3-576.4', thin laminae with some carbonate and algal zones, corroded and eroded upper surface. Thin reddish claystone at 581.8', similar to lower fracture fill. Stylolite at 582'. From 582.9-583.6', claystone, black (7.5YR2.5/) includes thin (~1/16") subhorizontal gypsum. 588-596.4': Gypsum, dark gray, coarse, subhorizontal bedding, with some thin carbonate or organic zones. Mud-filled horizontal separations at 588.8' and 589.1'. Mud filling fracture from 592-593.2' is clay, reddish brown (5YR4/4; damp), includes some clear gypsum crystals. Base of Tamarisk Member 596.4' Top of Culebra Dolomite Member 596.4-598.5': Dolomite, pinkish gray (7.5YR6/2, wet), sandy, minor clay; bedded to laminar at top with slight algal mounding (~0.1'); some low-angle cross-cutting; vuggy along bedding.	End coring 3/31/04 @ 601'. Begin 4/1/04
	601'–610	Cut 20.5'; recovered 7.2'	2.6 ft in segments > 4" long (RQD = 36.1)	no core recovered	598.5-607.5': Dolomite, light gray (7.5YR7/2); thin laminae (~1/8") in beds of darker dolomite (7.5YR6/2) separated by thicker (~1") light gray dolomite; less porous, less sandy than above; vugs ~1/16-1/4". Possible cavernous porosity fill by mudstone, red (2.5YR4/6) at ~601'.	



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

Logged by: Dennis W. Powers, Ph.D. | Date: 4/01/04-4/05/04

Run Number	Depth (ft)	% Recovered	RQD	Profile (Rock Type)	Description	Remarks
4	610 620			no core recovered	Bit drop from 617-619', lost circulation to poor circulation during remaining coring, reaming, and deepening. 621-623.5': Claystone, silty, grayish-brown (2.5YR5/2, moist), silty, appears laminated. 623.5-625.5': Dolomite, light gray (2.5Y7/2), fractured, with silt and dolomite filling fractures (CU-4)	Culebra core loss arbitrarily assigned below 607'; all core locations from 601-607' are arbitrary but consistent with lithology of upper Culebra.
5	621.5' 630 636.5'	Cut 15'; recovered 14.5'	1.6' in segments < 4" long (RQD = 92.1)		Base of Culebra Dolomite Member 625.5' Top of Los Medaños Member 625.5-626.9': Claystone, black to gray, with thin subhorizontal gypsum. Includes large clast of Culebra. 626.9-627.2': Mudstone, dusky red (2.5YR3/2, moist), with surface indicating smeared intraclast textures. 627.2-628': Claystone, gray, with thin subhorizontal gypsum; dolomite clasts to ~1". 628-629.2': Siltstone, argillaceous, gray, laminated, deformed. 629.2-630.5': Claystone, gray, with thin subhorizontal gypsum; dolomite clasts to ~1". 630.5-632': Claystone, silty, dusky red (2.5YR3/2), calcarous; clasts of gypsum to 2", small claystone clasts ~ 1/4'. 632-636.5': Siltstone, reddish brown (2.5YR5/4), calcareous; pseudobedding; washed out surface features indicating smeared intraclast textures; some gray mottling; gypsum in lower 1'. Cuttings below 636.5 not included in description. Drilling rates indicate gypsum from 637-644'. Cuttings delayed.	End coring 4/1/04 @ 636.5' Deepen to 644' on 4/6/04 using fresh water with EZ mud. Cuttings may not be representative.
N/A	640 650 660 670 680 690	N/A C-59 940' C-60 944'	N/A			

"Shale shaker" set up at SNL-1 to collect cuttings circulated out of drillhole with drilling fluid.

Set up to collect and describe cuttings at SNL-1.

Appendix D
Geophysical Logs

Geophysical logging of SNL-1 was conducted by Geophysical Logging Services, 6250 Michele Lane, Prescott, AZ 86305, on April 6, 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 April 6, 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-1 had been cored and drilled to about 644 ft bgl at the time of logging. A conductor casing had been placed to a depth of 30 ft bgl. The fluid level was brought up to the surface at the time logging began, but it dropped during logging.

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 3,512 ft amsl on the logs, based on the elevation of the well pad surface (3,511.56 ft amsl) measured prior to drilling. A benchmark placed near the drillhole after completion has an elevation of 3,310.62 ft amsl (see Fig. 1-5 and Table 1-1 in the main text).

The logging date on printed copies of geophysical logs maintained as records has been corrected by hand to indicate the correct logging date of April 6, 2004.

Geophysical Logging Services logging vehicle (right) set up and logging SNL-1 on April 6, 2004. The caliper tool is resting on top of the connector on the surface casing (below) after a logging run of SNL-1. The top of the connector is the reference point (0 ft depth) for logging and setting casing.

Appendix E
Permitting and Completion Information

A case file for SNL-1 (C-2953) 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-2953.

Information on management of well-drilling wastes for SNL-1 is not included; at the time of basic data report preparation, these wastes were still being characterized for disposal.

Two typographical errors on the reproductions of the memorandum from Powers to Richardson and Beauheim (p. 60) have been corrected. The first correction is the depth of the bit drop from 517 ft to 617 ft (first bullet item). The second correction is the spelling of "interval" in the next to last paragraph of the letter.

Dennis W. Powers, Ph. D.

Consulting Geologist

April 7, 2004

Ron Richardson
Field Lead
WRES

Rick Beauheim
Hydrology Lead
Sandia National Laboratories

Re: Screen Interval for Culebra Dolomite Member in SNL-1

Our discussions regarding the Culebra Dolomite Member in SNL-1 indicate that the best interval to screen is from 620-593.75 ft below the top of the connector on the permanent conductor casing (reference point). This decision is based on geophysical logs completed on April 6, 2004 (see attached figure) and cores recovered during drilling.

These are the factors we considered in this decision for SNL-1:

- The Culebra interval, as indicated by the natural gamma geophysical log, is from ~626–596 ft below the reference point. This interval is 30 ft thick, which is above average around the WIPP site. During drilling, a short (2 ft) drop of the drill string at about 617 ft and lost circulation indicate relatively high permeability at SNL-1 in the Culebra.
- The screened or slotted section of the casing joint is 26.25 ft long. This will provide a screened interval that will incorporate all of the Culebra above basal clay zones.
- Core from the basal Culebra (below 620 ft) included light gray argillaceous zones that are soft; these also show up on the natural gamma log. The screen interval was placed above this zone to prevent squeezing into the screen and clogging flow.
- The laminated claystone and mudstone (M-2/H-2) below the Culebra was cored. It includes deformed gray siltstones below the Culebra and a typical section below that to 636.5 ft. There is no salt in this section, and it does not need to be cemented. Cuttings and drilling rates indicate that A-1 was encountered from 637 to 644 ft.
- Core and geophysical logs above the Culebra indicate the anhydrite/gypsum unit (A-2) is relatively intact (there are some fractures in the lower part) and separates the Culebra from the Tamarisk Member mudstone (M-3/H-3) by 20 ft. The top of the sand pack is below thin claystones, and the bentonite seal and cement should separate the Culebra and the Tamarisk mudstone from circulation through the annulus.

By placing the bottom of the screened interval at 620 ft, clays in the lower Culebra should be prevented from squeezing into the screens. The top of the screened interval at 593.75 ft should be isolated from M-3/H-3. The top of the sand pack should not be higher than about 584 ft, and bentonite to 579 ft will prevent circulation into M-3/H-3 through the annulus.

To provide sump space below the screened interval, 9.5 ft of blank casing with an end cap should be added below the screened interval. The hole should be separated geologically from the lower Los Medaños Member, and the sand pack can be started from the bottom of the hole.

I believe this letter summarizes our discussions and presents the hydrological and geological justification for setting the screened interval and preparing SNL-1 for completion.

Sincerely,

Dennis W Powers

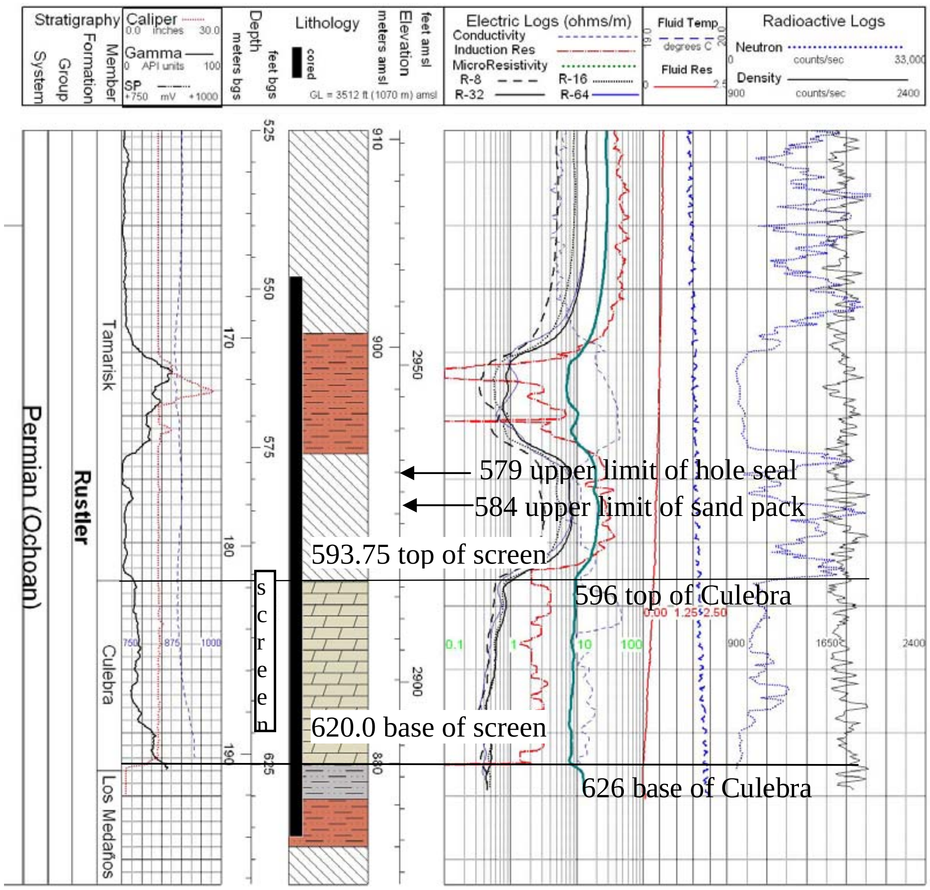
Dennis W. Powers

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

April 7, 2004

Partial Geophysical Log of SNL-1



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

April 9, 2004

Rey Carrasco
Geotechnical Engineering
Washington TRU Solutions
Carlsbad, NM 88220

Storage and Retention of Cores and Rock Samples from SNL-1

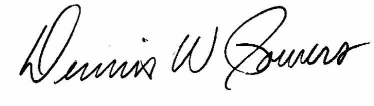
Background
Cores and cutting samples have been collected from drillhole SNL-1 in support of the drilling and testing program to investigate the hydrology of the Culebra Dolomite Member of the Rustler Formation as well as other units of hydrogeological significance to the program. These samples were collected under my supervision, and the chain-of-custody has been maintained by me or WRES personnel. SNL-1 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-1 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-1 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-1 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 approved for publication in the basic data report for SNL-1.



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*

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 03/08/04 File No. C-2953 Expl.

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

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

3. The well is to be located in the NE 1/4 SW 1/4 NW 1/4, Section 16 Township 21 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 State of New Mexico

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 600' 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 An original permit was received on this particular well on 25 February 2003, however, drilling was deferred until adequate funding was acquired (see attached correspondence).. The State Engineer file number is C-2953. As described in the original permit application, this well is to be drilled as an exploration/monitoring well only. It will be drilled to total depth of 577' - 600' bgs. Casing an cement inspections have been identified as hold points pending site inspection 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. Once the initial pump test is completed, this well will be used for routine monitoring purposes (e.g., water level measurements).

2004 MAR -8 PM 3:36

STATE ENGINEER OFFICE ROSWELL NEW MEXICO

I, Douglas C. Lynn, WIPP Land Use Coordinator, affirm that the foregoing statements are true to the best of my knowledge and belief and that development shall not commence until approval of the permit has been obtained.

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

By: [signature] for

Subscribed and sworn to before me this 8th day of March, A.D., 2004

My commission expires 02/19/07 [signature: Mary Ann Walker]
Notary Public
#298273

Number of this permit__________

ACTION OF STATE ENGINEER

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

see attached conditions of approval

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

Proof of application of water to beneficial use shall be filed on or before N/A x20x

Witness my hand and seal this 10th day of March, A.D., 2004

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

By:____________________

Art mason, District II Supervisor

INSTRUCTIONS

This form shall be executed, preferably typewritten, in triplicate and shall be accompanied by a filing fee of $25.00. 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.

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: 298273
File Nbr: C 02953

Mar. 10, 2004

DOUG LYNN
U.S. DEPT. OF ENERGY
CARLSBAD FIELD OFFICE, WIPP
PO BOX 3090
CARLSBAD, NM 88221-3090

Greetings:

Enclosed is your copy of the Exploratory Permit which has been approved. In accordance with the conditions of approval, the well can only be tested for 10 cumulative days, and the well is to be plugged on or before 03/31/2005, unless a permit to use the water is acquired from this office.

Sincerely,

M. Wolf
for 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

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.

C2 No water shall be diverted from this well except for testing purposes which shall not exceed ten (10) cumulative days, and well shall be plugged or capped on or before 03/31/2005, unless a permit to use water from this well is acquired from the Office of the State Engineer.

LOG The Point of Diversion C 02953 EXPL must be completed and the Well Log filed on or before 03/31/2005.

ACTION OF STATE ENGINEER

Notice of Intention Rcvd: Date Rcvd. Corrected:
Formal Application Rcvd: 03/08/2004 Pub. of Notice Ordered:
Date Returned - Correction: Affidavit of Pub. Filed:

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

Witness my hand and seal this 10 day of Mar A.D., 2004

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

By: ______________________
Art Mason

Trn Desc: C 02953 EXPL

File Number: C 02953
Trn Number: 298273

page: 1

K H. LYONS
IISSIONER

State of New Mexico
Commissioner of Public Lands
310 OLD SANTA FE TRAIL
P.O. BOX 1148
SANTA FE, NEW MEXICO 87504-1148

COMMISSIONER'S
Phone (505) 827-
Fax (505) 827-57
www.nmstatelands

August 26, 2003

Doug Lynn
US Department of Energy
PO Box 3080
Carlsbad, NM 88221

Re: Water Development Easement No. WD-120

Dear Mr. Lynn:

Enclosed is an approved copy of the captioned of water development easement.

If you have any questions, please feel free to contact this office at (505) 827-5728 or 5729.

Sincerely,

Lorrie Gasca, Management Analyst
Surface Resources Division

PATRICK H. LYONS
COMMISSIONER

State of New Mexico
Commissioner of Public Lands
310 OLD SANTA FE TRAIL
P.O. BOX 1148
SANTA FE, NEW MEXICO 87504-1148

COMMISSIONER'S OFFICE
Phone (505) 827-5760
Fax (505) 827-5766
www.nmstatelands.org

August 29, 2003

Doug Lynn
US Department of Energy
PO Box 3090
Carlsbad, NM 88221-3090

Re: Right-of-Way Easement No. RW-28535

Dear Mr. Lynn:

Enclosed is an approved copy of the captioned grant of right-of-way easement. Also, enclosed are "Affidavit of Completion" forms to be completed and returned to this office upon completion of the project.

If any corrections are necessary, please let us know and we will retype or amend this lease as necessary.

If you have any questions, please feel free to contact this office at the above address or at (505) 827-5728 or 5729.

Sincerely,

Lorrie Gasca, Management Analyst
Surface Resources Division

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-109177
2805(080)whs

JUN 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 an access road across BLM lands to accommodate a proposed ground water monitoring well situated on adjacent state trust lands, 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. 15: NW¼SW¼,S½SW¼,SW¼SE¼.

The access road contains approximately 2.956 acres on Federal Lands as described above.

A plat showing the right-of-way described above is attached hereto as Exhibit A and made a part hereof.

The right-of-way herein granted and reserved is for the full use of the above described property by the U. S. Department of 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 March 6, 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 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. Exhibit B.

D. Attached are standard stipulations for permanent resource roads. Exhibit A.

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

Dated this 17th day of June, 2003.

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

EXHIBIT A
June 17, 2003

BLM Serial Number: NM-109177
Company Reference: SNL #1

STANDARD STIPULATIONS FOR PERMANENT RESOURCE ROADS
CARLSBAD FIELD OFFICE, BLM

A copy of the grant and attachments, including stipulations and map, will be on location during construction. BLM personnel may request to view a copy of your permit during construction to ensure compliance with all stipulations.

The holder/grantee/permittee shall hereafter be identified as the holder in these stipulations. The Authorized Officer is the person who approves the Application for Permit to Drill (APD) and/or Right-of-Way (ROW).

GENERAL REQUIREMENTS

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

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

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

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

E. The holder shall minimize disturbance to existing fences and other improvements on public domain surface. The holder is required to promptly repair improvements to at east their former state. Functional use of these improvements will be maintained at all times. The holder will make a

Exhibit A
NM-109177
June 17, 2003

When necessary to pass through a fence line, the fence shall be braced on both sides of the passageway prior to cutting of the fence.

Holder agrees to comply with the following stipulations:

1. ROAD WIDTH AND GRADE

The road will have a driving surface of 14 feet (all roads shall have a minimum driving surface of 12 feet, unless local conditions dictate a different width). The maximum grade is 10 percent unless the box below is checked. Maximum width of surface disturbance from construction will be 30 feet.

/__/ Those segments of road where grade is in excess of 10% for more than 300 feet shall be designed by a professional engineer.

2. CROWNING AND DITCHING

Crowning with materials on site and ditching on one side of the road on the uphill side will be required. The road cross-section will conform to the cross section diagrams in Figure 1. If conditions dictate, ditching may be required for both sides of the road; if local conditions permit, a flat-bladed road may be considered (if these conditions exist, check the appropriate box below). The crown shall have a grade of approximately 2% (i.e., 1" crown on a 12' wide road).

/__/ Ditching will be required on both sides of the roadway as shown on the attached map or as staked in the field.

/__/ Flat-blading is authorized on segment(s) delineated on the attached map.

3. DRAINAGE

Drainage control shall be ensured over the entire road through the use of borrow ditches, outsloping, insloping, natural rolling topography, lead-off (turnout) ditches, culverts, and/or drainage dips.

A. All lead-off ditches shall be graded to drain water with a 1 percent minimum to 3 percent maximum ditch slope. The spacing interval for lead-off ditches shall be determined according to the following table, but may be amended depending upon existing soil types and centerline road slope (in %):

SPACING INTERVAL FOR TURNOUT DITCHES

Percent slope	Spacing interval
0% - 4%	400' - 150'
4% - 6%	250' - 125'
6% - 8%	200' - 100'
8% - 10%	150' - 75'

A typical lead-off ditch has a minimum depth of 1 foot below and a berm 6 inches above natural ground level. The berm will be on the down-slope side of the lead-off ditch. The ditch end will tie into vegetation whenever possible.

For this road the spacing interval for lead-off ditches shall be at

Exhibit A
NM-109177
June 17, 2003

/__/ 400 foot intervals.

/__/ _____ foot intervals.

/__/ locations staked in the field as per spacing intervals above.

/__/ locations delineated on the attached map.

B. Culvert pipes shall be used for cross drains where drainage dips or low water crossings are not feasible. The minimum culvert diameter must be 18 inches. Any culvert pipe installed shall be of sufficient diameter to pass the anticipated flow of water. Culvert location and required diameter are shown on the attached map (Further details can be obtained from the Carlsbad Field Office).

C. On road slopes exceeding 2%, drainage dips shall drain water into an adjacent lead-off ditch. Drainage dip location and spacing shall be determined by the formula:

$$\text{spacing interval} = \frac{400'}{\text{road slope in \%}} + 100'$$

Example: 4% slope: spacing interval = $\frac{400}{4} + 100 = 200$ feet

4. TURNOUTS

Unless otherwise approved by the Authorized Officer, vehicle turnouts will be required. Turnouts will be located at 2000-foot intervals, or the turnouts will be intervisible, whichever is less. Turnouts will conform to the following diagram:

```
______________________________________________________________________________

- - - - - - - - - - - - - - CENTER LINE OF ROADWAY - - - - - - - - - - - - - - -
_________   ___  __  ___  __  ___  __  ___  __  ___  __  ___  __  ___   _________
         ↑                                                             ↑
         |                      TURNOUT - 10' WIDE                     |
         |←---25'---→|←---------------50---------------→|←---25'----→|

                     STANDARD TURNOUT - PLAN VIEW
```

5. SURFACING

Surfacing of the road or those portions identified on the attached map may, at the direction of the Authorized Officer, be required, if necessary, to maintain traffic within the right-of-way with caliche, gravel, or other surfacing material which shall be approved by the Authorized Officer. When surfacing is required, surfacing materials will be compacted to a minimum thickness of six inches with caliche material. The width of surfacing shall be no less than the driving surface. Prior to using any mineral materials from an existing or proposed Federal source, authorization must be obtained from the Authorized Officer.

6. CATTLEGUARDS

Where used, all cattleguard grids and foundation designs and construction shall meet the American Association of State Highway and Transportation Officials (AASHTO) Load Rating H-20, although AASHTO U-80 rated grids shall be required where heavy loads (exceeding H-20 loading), are anticipated (See BLM standard drawings for cattleguards). Cattleguard grid length shall not be less

Exhibit A
NM-109177
June 17, 2003

than 8 feet and width of not less than 14 feet. A wire gate (16-foot minimum width) will be provided on one side of the cattleguard unless requested otherwise by the surface user.

7. MAINTENANCE

The holder shall maintain the road in a safe, usable condition. A maintenance program shall include, but not be limited to blading, ditching, culvert installation, culvert cleaning, drainage installation, cattleguard maintenance, and surfacing.

8. PUBLIC ACCESS

Public access along this road will not be restricted by the holder without specific written approval being granted by the Authorized Officer. Gates or cattleguards on public lands will not be locked or closed to public use unless closure is specifically determined to be necessary and is authorized in writing by the Authorized Officer.

9. CULTURAL RESOURCES

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

10. NOXIOUS WEEDS

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

SPECIAL STIPULATIONS:

The route is identified as habitat for the lesser prairie chicken; therefore, all construction activities will be restricted to the hours of 9:00 am through 3:00 am for the period of March 15 through June 15.

EXHIBIT B
June 17, 2003

BLM Serial No.: NM-109177
Company Reference: SNL #1

Seed Mixture for LPC Sand/Shinnery Sites

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

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

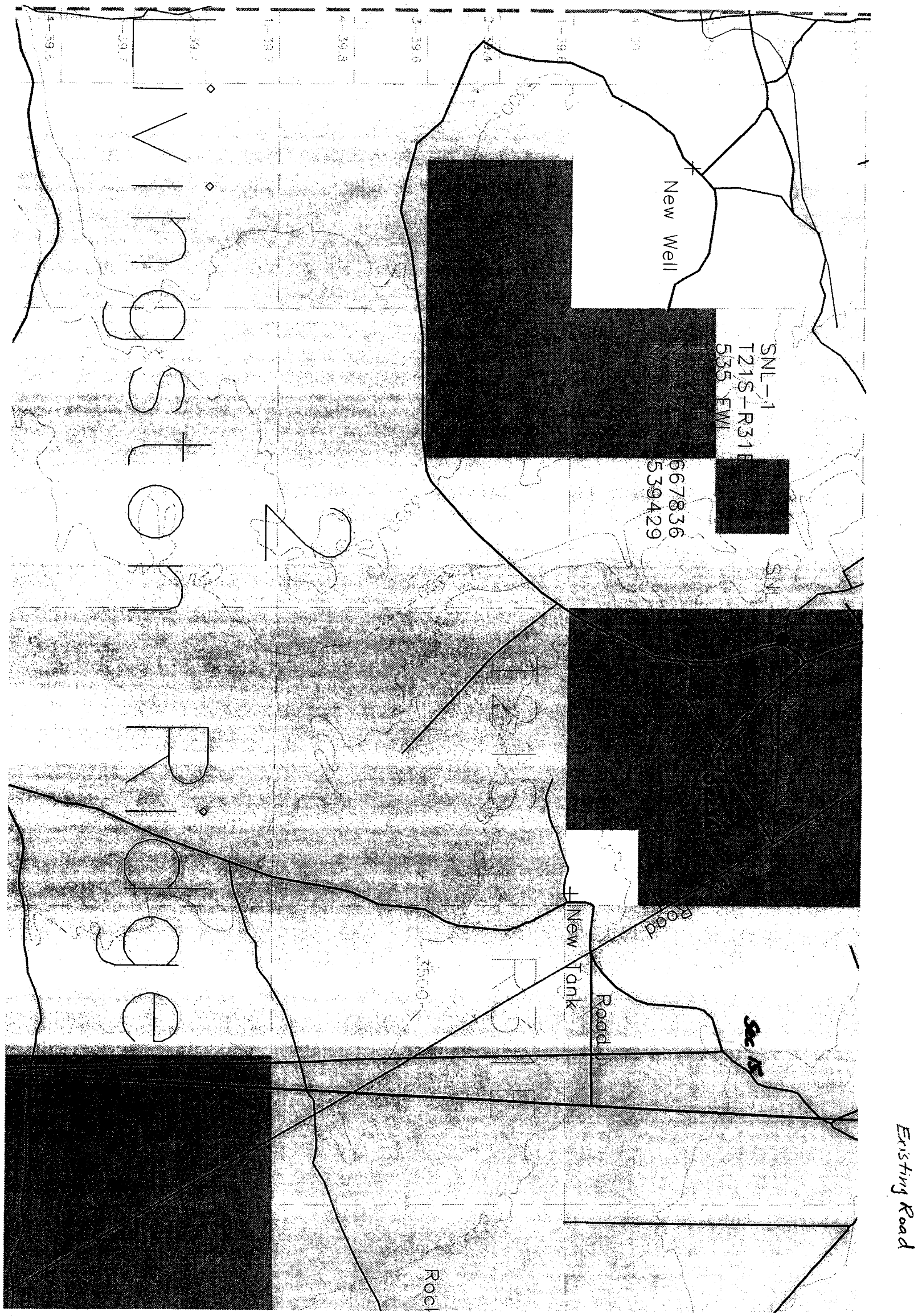
Species to be planted in pounds of pure live seed* per acre:

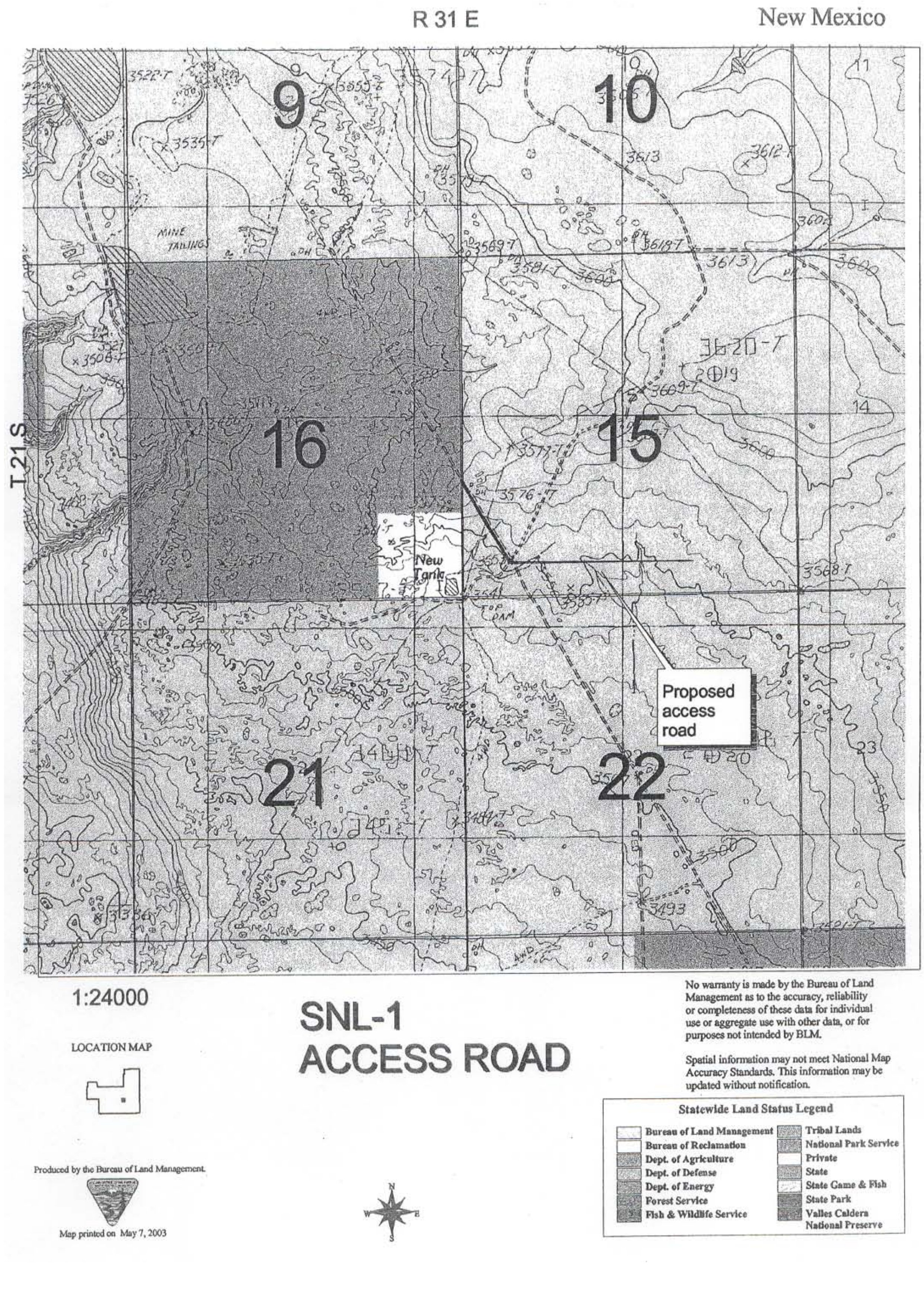
Species	lb/acre
Plains Bristlegrass	5lbs/A
Sand Bluestem	5lbs/A
Little Bluestem	3lbs/A
Big Bluestem	6lbs/A
Plains Coreopsis	2lbs/A
Sand Dropseed	1lbs/A
**Four-winged Saltbush	5lbs/A

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

*Pounds of pure live seed:

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


Livingston Ridge
New Well
SNL-1
New Tank
Road
Existing Road


R 31 E
New Mexico
T 21 S
9
10
11
14
15
16
21
22
23
Mine Tailings
New Tank
Proposed access road
1:24000
SNL-1
ACCESS ROAD
LOCATION MAP
No warranty is made by the Bureau of Land Management as to the accuracy, reliability or completeness of these data for individual use or aggregate use with other data, or for purposes not intended by BLM.
Spatial information may not meet National Map Accuracy Standards. This information may be updated without notification.
Statewide Land Status Legend
Bureau of Land Management
Bureau of Reclamation
Dept. of Agriculture
Dept. of Defense
Dept. of Energy
Forest Service
Fish & Wildlife Service
Tribal Lands
National Park Service
Private
State
State Game & Fish
State Park
Valles Caldera National Preserve
Produced by the Bureau of Land Management.
Map printed on May 7, 2003
N
S
E
W

Department of Energy
Carlsbad Field Office
P. O. Box 3090
Carlsbad, New Mexico 88221

OCT 2 2 2003

Mr. Randy Foote, Manager
Mississippi Potash, Inc.
P.O. Box 101
1996 E. Potash Mines Rd
Carlsbad, NM 88220

Dear Mr. Foote

This letter is to confirm agreements reached as a result of discussions held on October 14, 2003 between representatives of Mississippi Potash, Inc. (MPI) and representatives of the Department of Energy's (DOE's) Waste Isolation Pilot Plant (WIPP) regarding the drilling of monitoring well SNL-1 that DOE plans to locate near the Mississippi East Facility. Our reason for requesting the discussions was to address technical and/or operational concerns that MPI might have with the proposed well or its location, consistent with DOE's policy to maintain open dialogue with all WIPP neighbors. Through the course of the discussions, a consensus was reached that MPI had no objection to the monitoring well so long as DOE adhered to the drilling plan presented in the meeting. Before beginning drilling operations, DOE would like to obtain MPI's written concurrence with the enclosed summary of the discussions held and the agreements reached.

Participants in the discussions included: Tom McGuire, MPI Mine Engineer; Rick Beauheim and Tom Pfeifle, Sandia National Laboratories (Sandia); and Doug Lynn, Washington Regulatory and Environmental Services (WRES). Sandia and WRES serve as the WIPP Scientific Advisor and the WIPP Management and Operating Contractor to DOE, respectively.

Purpose of WIPP Monitoring Well, SNL-1

Both the certification issued by the US Environmental Protection Agency (EPA) and the hazardous waste facility permit approved by the New Mexico Environment Department require that the DOE actively monitor the WIPP site to ensure protection of the environment, the health and safety of workers and the public, and proper characterization of the waste disposal system. As a result, the DOE has developed and implemented a formal monitoring program to changes in site hydrologic conditions (flow rate and direction).

WIPP hydrologic conditions are monitored using approximately 70 wells completed primarily to the Culebra Dolomite Member of the Rustler Formation because this unit is the most transmissive saturated unit in the basin. Recent observations have revealed a general long-term rise in Culebra water levels over a broad area including Nash Draw and short-term fluctuations of unknown origin at localized areas.

CBFO:OEC:HJ:IW:03-3146:UFC:5480

Mr. Randy Foote -2- OCT 22 2003

As one of the regulators of the WIPP, the EPA has asked DOE to explain the observed water-level changes, to assess the impact of the changes on the performance of WIPP, and to justify continued use of current groundwater conceptual flow models.

The DOE must address EPA's requests to explain the observed water-level changes and to justify continued use of the current Culebra flow model. Three scenarios that have the potential to affect water levels are proposed for investigation: (1) possible recharge of the Culebra from brine discharges originating from potash operations in and near Nash Draw; (2) possible leakage through boreholes that are poorly cased or improperly plugged and abandoned; and (3) possible influences of hydraulic heads in Nash Draw on Culebra heads under Livingston Ridge through high transmissivity conduits resulting from upper Salado dissolution in the geologic past. SNL-1 is one of the seven wells that are planned mostly located west and north of the WIPP to investigate these water-level-rise scenarios.

Location and Drilling Plan for WIPP Monitoring Well, SNL-1

The DOE plans to drill SNL-1 in Section 16, T21S, R31E just south-southwest of MPI's Mississippi East facility. The well has been permitted by the New Mexico Office of the State Engineer (File No. C-2953, RW 28535). In addition, the US Bureau of Land Management has granted right-of-way (ROW) approval for the proposed well and road. Location surveys of the well pad (100-ft x 100-ft) and a 20-ft-road easement providing access to the pad (included herewith as Exhibit A) have been completed as required by the permit application and ROW approval processes.

The well would be drilled to a TD coincident with the top of the Salado Formation (estimated to be 690 feet), would be cemented from TD to approximately 20 feet below the base of the Culebra Dolomite (estimated to be a depth of 620 feet), and then would be completed to the Culebra using a gravel-packed fiberglass screen and casing cemented to surface. Drilling is expected to begin late in CY 2003 or early in CY 2004.

Potential Concerns with the Location of SNL-1

MPI expressed two potential concerns with the location of SNL-1: (1) the well pad and road may infringe on MPI's surface business lease boundary and (2) the well may be directly above and/or bottom out near MPI's underground mining operations or haulage ways. To evaluate these concerns, MPI performed its own survey of the pad to locate the position of the pad relative to the MPI property.

The MPI survey information has shown the well pad and road easement are located outside the MPI business lease boundary. However, the current well pad is partially over an inactive mined-out area as shown in the enclosed Figure so the potential exists for the well to be drilled and terminated directly above a mined opening.

CBFO:OEC:HJ:IW:03-3146:UFC:5480

OCT 22 2003

Mr. Randy Foote -3-

Potash in the vicinity of the planned well is produced from the 10th ore zone of the McNutt Member of the Salado Formation at a depth of approximately 1,268 feet so the vertical cover between the mining horizon and the expected TD of SNL-1 (i.e., 690 feet) is about 578 feet. We believe that MPI considers this cover to be adequate to avoid interference between well activities and its underground operations.

Agreements Reached

MPI and the DOE, through its representatives from Sandia and WRES, reached the following agreements:

- Although the SNL-1 pad and road do not infringe on the MPI business lease, the pad is partially over a portion of MPI's inactive mined-out areas (see the enclosed Figure). However, sufficient vertical cover (about 578 feet) exists between the mine workings and the well TD to avoid interference between well activities and MPI's underground operations. Nevertheless, the DOE agrees to drill SNL-1 on the eastern portion of the well pad so that the well or its TD is not positioned directly above any underground workings.
- The DOE will provide MPI with the date when drilling of SNL-1 will be initiated.
- During the drilling and completion of SNL-1, the DOE will guarantee access to the well pad by MPI personnel to allow observation of drilling/coring/completion activities and any subsequent hydraulic testing.

Concurrence

The DOE believes it has accurately documented MPI's concerns about the proposed location of WIPP monitoring well SNL-1 and has provided information that addresses all MPI concerns. If this letter is incorrect, and MPI still has concerns about the proposed location of WIPP monitoring well SNL-1, please call me at (505) 234-7349 and let me know. If this letter is correct, please sign the enclosed concurrence statement and return to me either by mail or fax (505) 234-7061. The DOE appreciates your cooperation in this process.

Sincerely

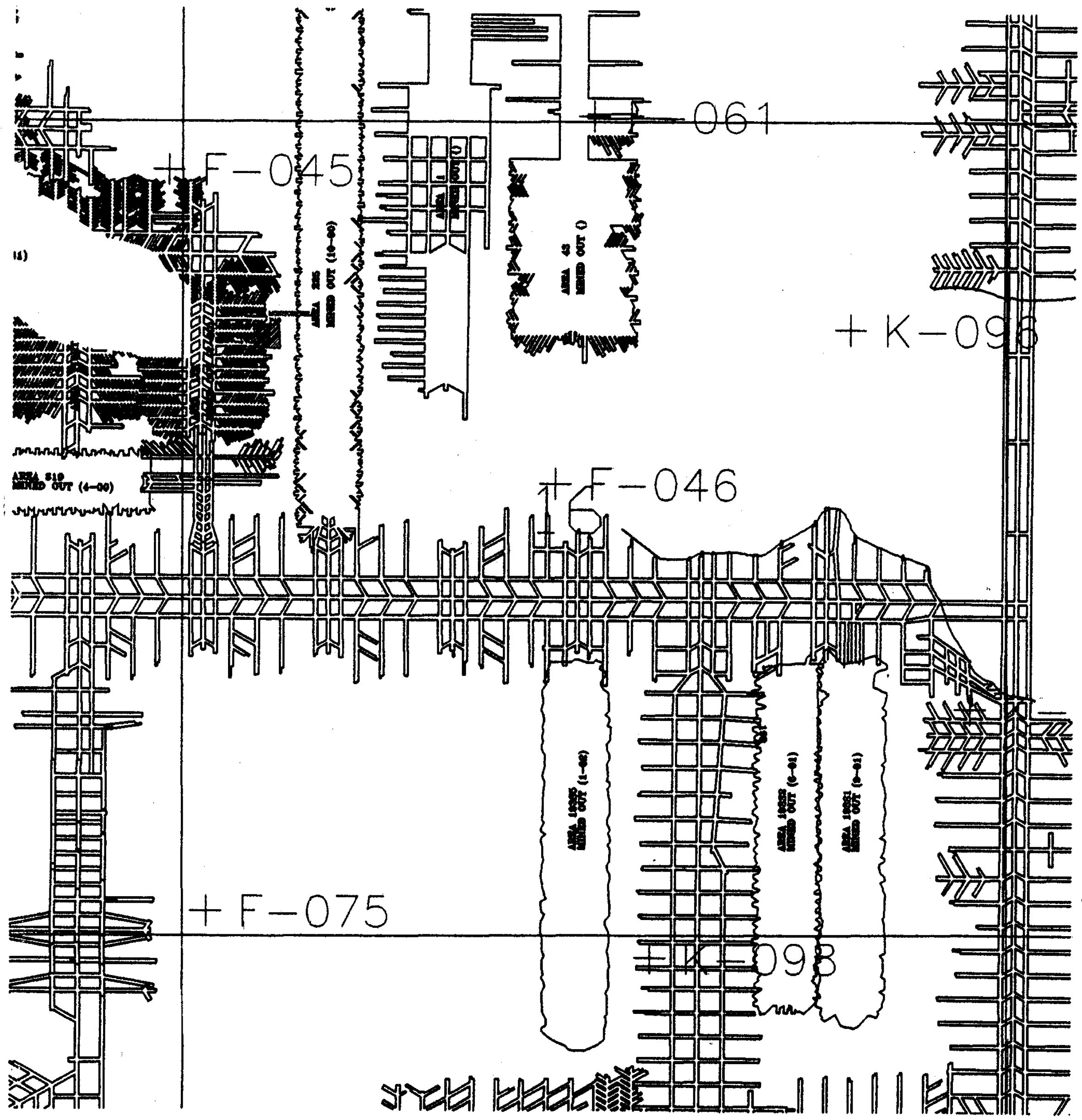
Harold Johnson

Harold Johnson
Acting Assistant Manager
for Environmental Compliance

Enclosures

Mr. Randy Foote -4- OCT 2 2 2003

cc:
R. Patterson, CBFO
S. Casey, CBFO
T. McGuire, Mississippi Potash Inc.
R. Beauheim, SNL
T. Pfeifle, SNL
D. Lynn, WRES
J. Siegel, WRES
CBFO M&RC


061
F-045
F-046
F-075

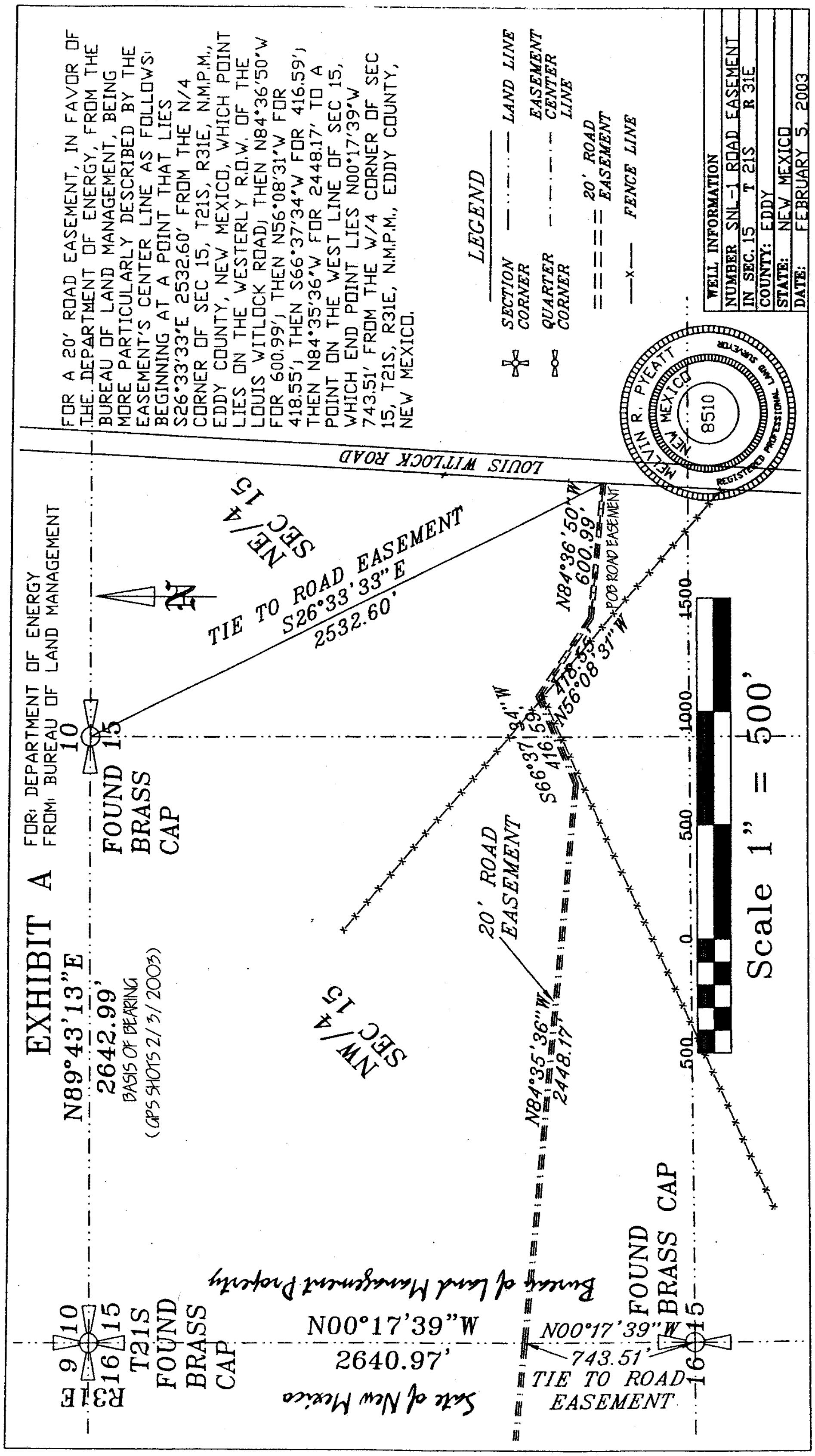


EXHIBIT A
FOR: DEPARTMENT OF ENERGY
FROM: BUREAU OF LAND MANAGEMENT
FOR A 20' ROAD EASEMENT, IN FAVOR OF THE DEPARTMENT OF ENERGY, FROM THE BUREAU OF LAND MANAGEMENT, BEING MORE PARTICULARLY DESCRIBED BY THE EASEMENT'S CENTER LINE AS FOLLOWS: BEGINNING AT A POINT THAT LIES S26°33'33"E 2532.60' FROM THE N/4 CORNER OF SEC 15, T21S, R31E, N.M.P.M., EDDY COUNTY, NEW MEXICO, WHICH POINT LIES ON THE WESTERLY R.O.W. OF THE LOUIS WITLOCK ROAD; THEN N84°36'50"W FOR 600.99'; THEN N56°08'31"W FOR 418.55'; THEN S66°37'34"W FOR 416.59'; THEN N84°35'36"W FOR 2448.17' TO A POINT ON THE WEST LINE OF SEC 15, WHICH END POINT LIES N00°17'39"W 743.51' FROM THE W/4 CORNER OF SEC 15, T21S, R31E, N.M.P.M., EDDY COUNTY, NEW MEXICO.
LEGEND
SECTION CORNER
QUARTER CORNER
LAND LINE
EASEMENT CENTER LINE
20' ROAD EASEMENT
FENCE LINE
MELVIN R. PYEATT
NEW MEXICO
8510
REGISTERED PROFESSIONAL LAND SURVEYOR
WELL INFORMATION
NUMBER SNL-1 ROAD EASEMENT
IN SEC. 15 T 21S R 31E
COUNTY: EDDY
STATE: NEW MEXICO
DATE: FEBRUARY 5, 2003
N89°43'13"E
2642.99'
BASIS OF BEARING
(GPS SHOTS 2/3/2003)
10
15
FOUND BRASS CAP
TIE TO ROAD EASEMENT
S26°33'33"E
2532.60'
NE/4 SEC 15
NW/4 SEC 15
LOUIS WITLOCK ROAD
N84°36'50"W
600.99'
POB ROAD EASEMENT
N56°08'31"W
418.55'
S66°37'34"W
416.59'
20' ROAD EASEMENT
N84°35'36"W
2448.17'
Scale 1" = 500'
500 0 500 1000 1500
Bureau of Land Management Property
State of New Mexico
9 10
16 15
R31E
T21S
FOUND BRASS CAP
N00°17'39"W
2640.97'
N00°17'39"W
743.51'
TIE TO ROAD EASEMENT
16 15
FOUND BRASS CAP

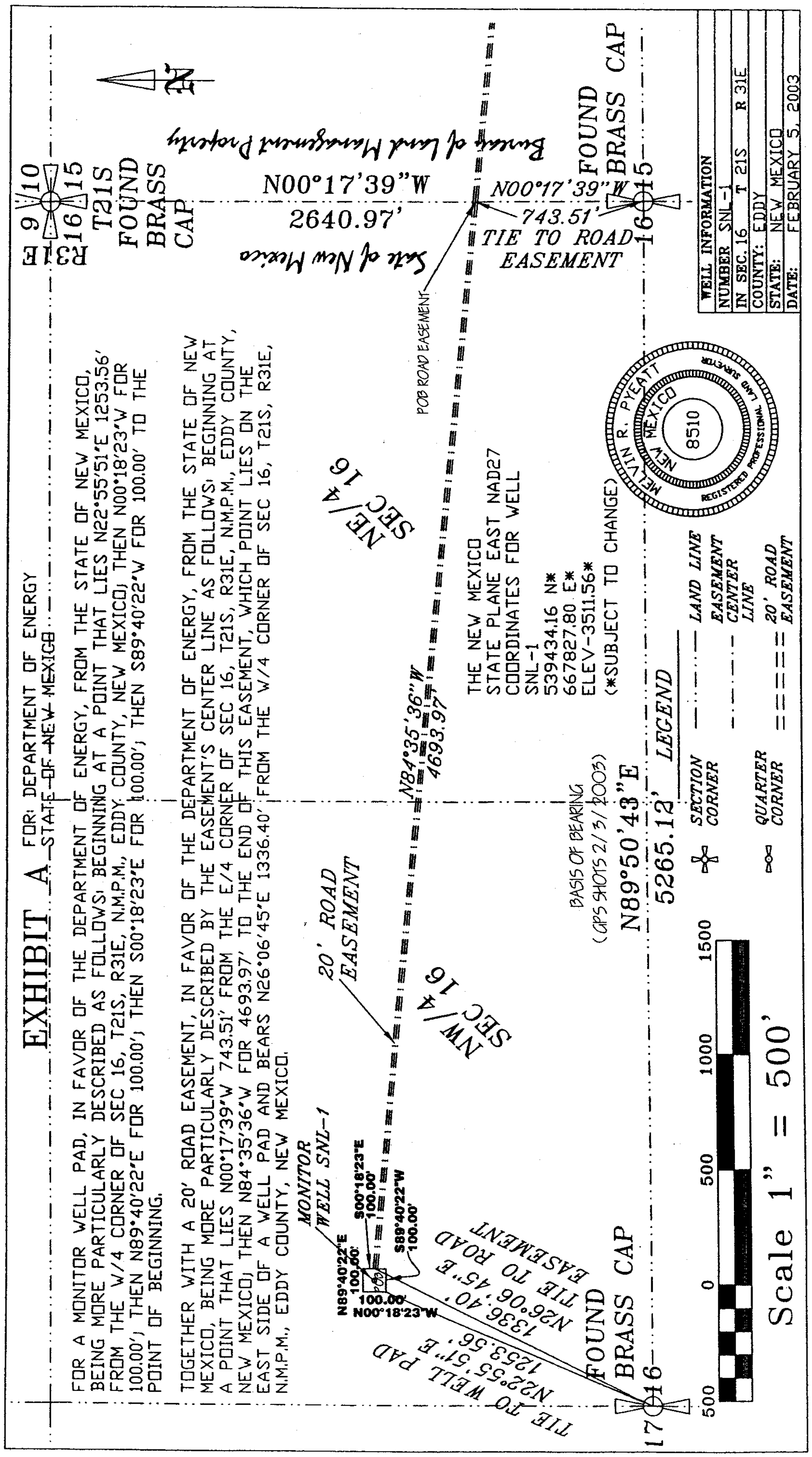


EXHIBIT A FOR: DEPARTMENT OF ENERGY
STATE OF NEW MEXICO
FOR A MONITOR WELL PAD, IN FAVOR OF THE DEPARTMENT OF ENERGY, FROM THE STATE OF NEW MEXICO, BEING MORE PARTICULARLY DESCRIBED AS FOLLOWS: BEGINNING AT A POINT THAT LIES N22°55'51"E 1253.56' FROM THE W/4 CORNER OF SEC 16, T21S, R31E, N.M.P.M., EDDY COUNTY, NEW MEXICO; THEN N00°18'23"W FOR 100.00'; THEN N89°40'22"E FOR 100.00'; THEN S00°18'23"E FOR 100.00'; THEN S89°40'22"W FOR 100.00' TO THE POINT OF BEGINNING.
TOGETHER WITH A 20' ROAD EASEMENT, IN FAVOR OF THE DEPARTMENT OF ENERGY, FROM THE STATE OF NEW MEXICO, BEING MORE PARTICULARLY DESCRIBED BY THE EASEMENT'S CENTER LINE AS FOLLOWS: BEGINNING AT A POINT THAT LIES N00°17'39"W 743.51' FROM THE E/4 CORNER OF SEC 16, T21S, R31E, N.M.P.M., EDDY COUNTY, NEW MEXICO; THEN N84°35'36"W FOR 4693.97' TO THE END OF THIS EASEMENT, WHICH POINT LIES ON THE EAST SIDE OF A WELL PAD AND BEARS N26°06'45"E 1336.40' FROM THE W/4 CORNER OF SEC 16, T21S, R31E, N.M.P.M., EDDY COUNTY, NEW MEXICO.
R31E 9 10 16 15
T21S
FOUND BRASS CAP
N
State of New Mexico
Bureau of Land Management Property
N00°17'39"W
2640.97'
POB ROAD EASEMENT
N00°17'39"W
743.51'
TIE TO ROAD EASEMENT
FOUND BRASS CAP
16 15
MONITOR WELL SNL-1
N89°40'22"E
100.00'
N00°18'23"W
100.00'
S00°18'23"E
100.00'
S89°40'22"W
100.00'
POB
20' ROAD EASEMENT
NE/4 SEC 16
NW/4 SEC 16
N84°35'36"W
4693.97'
TIE TO WELL PAD
N22°55'51"E
1253.56'
1336.40'
N26°06'45"E
TIE TO ROAD EASEMENT
FOUND BRASS CAP
17 16
THE NEW MEXICO STATE PLANE EAST NAD27 COORDINATES FOR WELL SNL-1
539434.16 N*
667827.80 E*
ELEV-3511.56*
(*SUBJECT TO CHANGE)
BASIS OF BEARING (GPS SHOTS 2/3/2003)
N89°50'43"E
5265.12'
LEGEND
SECTION CORNER
QUARTER CORNER
LAND LINE
EASEMENT CENTER LINE
20' ROAD EASEMENT
MELVIN R. PYEATT
NEW MEXICO
8510
REGISTERED PROFESSIONAL LAND SURVEYOR
500 0 500 1000 1500
Scale 1" = 500'
WELL INFORMATION
NUMBER SNL-1
IN SEC. 16 T 21S R 31E
COUNTY: EDDY
STATE: NEW MEXICO
DATE: FEBRUARY 5, 2003

CONCURRENCE STATEMENT:

We the undersigned concur with the content of this letter including the summary of the discussions held and agreements reached on October 14, 2003 regarding the location of WIPP monitoring well SNL-1.

10-28-03
Date

Randy Foote, Manager
Mississippi Potash Inc.
P.O. Box 101
1996 E. Potash Mines Rd
Carlsbad, NM 88220

10/22/2003
Date

Harold Johnson, Acting
Assistant Manager for
Environmental Compliance
US Department of Energy
Carlsbad Field Office
4021 National Parks Highway
Carlsbad, NM 88220

Revised June 1972

STATE ENGINEER OFFICE

WELL RECORD

Section 1. GENERAL INFORMATION

(A) Owner of well WASHINGTON TRU SOLUTIONS Owner's Well No. SNL-1
Street or Post Office Address P.O. BOX 2078
City and State CARLSBAD, NEW MEXICO 88221

Well was drilled under Permit No. C-2953 EXPL. and is located in the:

a. NE ¼ NW ¼ SW ¼ NW ¼ of Section 16 Township 21S 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 EDDY County.

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

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

Address 3410 MANKINS ODESSA, TEXAS 79764

Drilling Began 3-25-04 Completed 4-7-04 Type tools MUD ROTARY Size of hole 11 in.

Elevation of land surface or ____ at well is 3512 ft. Total depth of well 630 ft.

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

Section 2. PRINCIPAL WATER-BEARING STRATA

Depth in Feet		Thickness in Feet	Description of Water-Bearing Formation	Estimated Yield (gallons per minute)
From	To			
596	626	30	LIGHT BROWN DOLOMITE, RUSTLER FORMATION	15

Section 3. RECORD OF CASING

Diameter (inches)	Pounds per foot	Threads per in.	Depth in Feet		Length (feet)	Type of Shoe	Perforations	
			Top	Bottom			From	To
13-3/8	48	8	2.5 AGL	30	32.5			
5" FIBERGLASS	3.2	4	2' AGL	629.5	631.5	FIBERGLASS CAP ON BOTTOM	.020 SCREEN 593.7	620

Section 4. RECORD OF MUDDING AND CEMENTING

Depth in Feet		Hole Diameter	Sacks of Mud	Cubic Feet of Cement	Method of Placement
From	To				
0	30	18" 13-3/8 CSG		27	TRIMMIE
30	630	11"		380	TRIMMIE

Section 5. PLUGGING RECORD

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

____
State Engineer Representative

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

FOR USE OF STATE ENGINEER ONLY

Date Received

Quad ____ FWL ____ FSL ____

File No. ____ Use ____ Location No. ____

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 & BROWN SAND
4	7	3	WHITE CALICHE (MESCALERO)
7	350	343	REDDISH BROWN CALCAREOUS SANDY SILTSTONE & SILTY CLAYSTONE (MIDDLE DEWEY LAKE FORMATION)
350	400	50	REDDISH BROWN GYPSIFEROUS SANDY SILTSTONE & SILTY CLAYSTONE (LOWER DEWEY LAKE FORMATION)
400	462	62	WHITE GYPSUM BEDS WITH INTERMEDIATE GRAY TO REDDISH BROWN CLAYST (FORTY-NINER MEMBER OF RUSTLER FORMATION)
462	489	27	WHITE TO GRAYISH BROWN GYPSIFEROUS DOLOMITE (MAGENTA DOLOMITE MEMBER OF RUSTLER FORMATION)
489	596	107	WHITE GYPSUM BEDS WITH INTERMEDIATE GRAY TO REDDISH BROWN CLAYST (TAMARISK MEMEBER OF THE RUSTLER FORMATION)
596	626	30	LIGHT BROWN DOLOMITE (CULEBRA DOLOMITE MEMBER OF THE RUSTLER FORMATION)
626	630	4	DARK GRAY TO REDDISH BROWN GYPSIFEROUS CLAYSTONE (UPPER LOS MEDANOS MEMEBER 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.

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.

HALL ENVIRONMENTAL ANALYSIS LABORATORY

COVER LETTER

April 16, 2004

David Chace
Sandia National Lab
4100 National Parks Hwy.
MS1395
Carlsbad, NM 88220
TEL: (505) 235-0353
FAX (505) 234-0061

RE: WIPP Site

Order No.: 0403227

Dear David Chace:

Hall Environmental Analysis Laboratory received 1 sample on 3/29/2004 for the analyses presented in the following report.

These were analyzed according to EPA procedures or equivalent.

Reporting limits are determined by EPA methodology. No determination of compounds below these (denoted by the ND or < sign) has been made.

Please don't hesitate to contact HEAL for any additional information or clarifications.

Sincerely,

Andy Freeman, Business Manager
Nancy McDuffie, Laboratory Manager

4901 Hawkins NE ■ Suite D ■ Albuquerque, NM 87109
505.345.3975 ■ Fax 505.345.4107
www.hallenvironmental.com

Hall Environmental Analysis Laboratory Date: *16-Apr-04*

CLIENT:	Sandia National Lab	**Client Sample ID:**	SNL-1
Lab Order:	0403227	**Collection Date:**	3/25/2004 11:10:00 AM
Project:	WIPP Site		
Lab ID:	0403227-01	**Matrix:**	AQUEOUS

Analyses	Result	PQL	Qual	Units	DF	Date Analyzed
EPA METHOD 300.0: ANIONS						Analyst: BL
Fluoride	ND	50		mg/L	500	3/29/2004 5:34:46 PM
Chloride	190000	500		mg/L	5000	3/29/2004 4:00:00 PM
Bromide	440	50		mg/L	500	3/29/2004 5:34:46 PM
Phosphorus, Orthophosphate (As P)	ND	250		mg/L	500	3/29/2004 5:34:46 PM
Sulfate	15000	2500		mg/L	5000	3/29/2004 4:00:00 PM
Nitrate (As N)+Nitrite (As N)	ND	50		mg/L	500	3/29/2004 5:34:46 PM
EPA METHOD 310.1: ALKALINITY						Analyst: MAP
Alkalinity, Total (As CaCO3)	290	2.0		mg/L CaCO3	1	4/5/2004
Carbonate	ND	2.0		mg/L CaCO3	1	4/5/2004
Bicarbonate	290	2.0		mg/L CaCO3	1	4/5/2004
EPA 120.1: SPECIFIC CONDUCTANCE						Analyst: MAP
Specific Conductance	>199900	0.010		µmhos/cm	1	4/5/2004
EPA METHOD 6010C: DISSOLVED METALS						Analyst: NMO
Calcium	540	100		mg/L	100	4/5/2004 12:37:15 PM
Iron	ND	2.0		mg/L	100	4/5/2004 12:37:15 PM
Magnesium	4500	100		mg/L	100	4/5/2004 12:37:15 PM
Potassium	21000	1000		mg/L	1000	4/5/2004 1:04:20 PM
Sodium	91000	1000		mg/L	1000	4/5/2004 1:04:20 PM
EPA METHOD 150.1: PH						Analyst: MAP
pH	6.82	0.010		pH units	1	4/5/2004
EPA METHOD 160.1: TDS						Analyst: MAP
Total Dissolved Solids	330000	100		mg/L	2	3/31/2004

Qualifiers:
- ND - Not Detected at the Reporting Limit
- J - Analyte detected below quantitation limits
- B - Analyte detected in the associated Method Blank
- * - Value exceeds Maximum Contaminant Level
- S - Spike Recovery outside accepted recovery limits
- R - RPD outside accepted recovery limits
- E - Value above quantitation range

Page 1 of 1

1 / 10

HALL ENVIRONMENTAL ANALYSIS LABORATORY

CATION/ANION BALANCE SHEET FOR WATER ANALYSES

HEAL LAB NUMBER	SNL-1 0403227-01											
CATIONS	mg/L	meq/L	mg/L	meq/L	mg/L	meq/L	mg/L	meq/L	mg/L	meq/L	mg/L	meq/L
Sodium	91000.0	3958.24										
Potassium	21000.0	537.08										
Calcium	540.0	26.95										
Magnesium	4500.0	370.37										
Total Cations		4892.64										
ANIONS	mg/L	meq/L	mg/L	meq/L	mg/L	meq/L	mg/L	meq/L	mg/L	meq/L	mg/L	meq/L
Sulfate	15000	312.30										
Chloride	190000	5359.66										
Bicarbonate (CaCO3)	290	5.80										
Carbonate (CaCO3)	nd	*										
Phosphate (P)	nd	*										
Nitrite (N)	nd	*										
Nitrate (N)	nd	*										
Flouride	nd	*										
Bromide	440.00	5.51										
Total Anions		5683.27										
Elect. Cond. (µMhos/cm)	199900											
CATION/ANION RATIO		0.86										
% Difference		7										
TOTAL DISSOLVED SOLIDS RATIOS												
TDS (measured)	330000											
TDS (calculated)	322654											
Ratio meas TDS:calc TDS		1.0										
Ratio Meas. TDS:EC		1.65										
Ratio Calc. TDS:EC		1.61										
Ratio of anion sum:EC		2.8										
Ratio of cation sum:EC		2.4										

* Analyte not detected (below method detection limit).

** Values below 0.55 can be obtained in waters containing appreciable concentrations of free acid or alkalinity, or not within pH 6 to 9. Values much higher than 0.7 are possible in highly saline waters.

GENERALLY ACCEPTED RANGES

Cation/Anion balance: 0-3 meq/L- 0.2 meq/L, 3-10 meq/L- 2%, >10 meq/L - 5%

Ratio measured TDS:calculated TDS -- 1.0-1.2. Ratio Calculated TDS:EC -- 0.55-0.7. Ratio Measured TDS:EC--0.55-0.7. Ratio of anion sum:EC -- 0.9-1.1.

Ratio of cation sum:EC -- 0.9-1.1

CHAIN-OF-CUSTODY RECORD

HALL ENVIRONMENTAL ANALYSIS LABORATORY
4901 Hawkins NE, Suite D
Albuquerque, New Mexico 87109
Tel. 505.345.3975 Fax 505.345.4107
www.hallenvironmental.com

Client: Sandia National Labs
David Chace
Address: 4100 National Parks Hwy
Carlsbad, NM
88220

Phone #: (505) 234-0065
Fax #: (505) 234-0061

Accreditation Applied: NELAC ☐ USACE ☐
Other: ______

Project Name: WIPP
Project #: 68298/1.4.2.3
Project Manager: David Chace
Sampler: Ed Schaub
Sample Temperature: 6°C

Date	Time	Matrix	Sample I.D. No.	Number/Volume	Preservative: HgCl2	Preservative: HNO3	Preservative: H2SO4	HEAL No. 0403227
3-25-04	11:12	H2O	SNL-1	1/125mL		X		1
3-25-04	11:10	H2O	SNL-1	1/500mL	X			2
3-25-04	11:10	H2O	SNL-1	1/500mL			X	3

ANALYSIS REQUEST

	BTEX + MTBE + TMB's (8021)	BTEX + MTBE + TPH (Gasoline Only)	TPH Method 8015B MOD (Gas/Diesel)	TPH (Method 418.1)	EDB (Method 504.1)	EDC (Method 8021)	8310 (PNA or PAH)	RCRA 8 Metals	Cations (Na, K, Ca, Mg)	Anions (F, Cl, NO3, NO2, PO4, SO4)	8081 Pesticides / PCB's (8082)	8260 (VOA)	8270 (Semi-VOA)	Cation/Anion Balance	Dissolved Iron	pH	Air Bubbles or Headspace (Y or N)
1														X	X	X	
2														X	X	X	
3														X	X	X	

Date: 3-28-04 Time: 19:34 Relinquished By: (Signature) [signature]
Remarks: POTENTIALLY HIGH SALTS

Date: Time: Relinquished By: (Signature)
Remarks: [signature] 3/29/04 0845

Remarks: Potentially High Salts!!

Photograph showing the setup at SNL-1 with portable mud pits to collect and recycle the drilling fluid and separate the cuttings for disposal.

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.

BLM/CFO

TITLE PAGE/ABSTRACT/
NEGATIVE SITE REPORT
CARLSBAD FIELD OFFICE

<table>
<tr><td>1. BLM Report No.:</td><td>2. (ACCEPTED) (REJECTED)</td><td>3. NMCRIS No.: 82096</td></tr>
<tr><td colspan="2" rowspan="2">4. Title of Report (Project Title): A Class III Cultural Resource Survey for the Lee Federal No. 39 Well Pad and Access Road</td><td>5. Project Date(s):
January 31, 2003</td></tr>
<tr><td>6. Report Date:
February 7, 2003</td></tr>
<tr><td colspan="2" rowspan="2">7. Consultant Name & Address
Direct Charge: Sean Simpson
Name: Mesa Field Services
Address: P.O. Box 3072
Carlsbad, NM 88221-3072
Author's Name: Theresa Straight
Field Personnel Names: Theresa Straight
Phone: (505) 628-8885</td><td>8. Permit No.: 153-2920-02-L</td></tr>
<tr><td>9. Consultant Report No.:
MFS – 812</td></tr>
<tr><td colspan="2" rowspan="2">10. Sponsor Name and Address
Individual Responsible: Ron Richardson
Name: Westinghouse TRU Solutions, LLC
Address: P.O. Box 2078
Carlsbad, NM 88221
Phone: (505) 234-8395</td><td>11. For BLM use only</td></tr>
<tr><td>12. Acreage
Total acres surveyed: 21.31
Per Surface Ownership
Federal: 9.61
State: 11.7
Private: 0</td></tr>
<tr><td colspan="3">13. Location & Area (maps attached if negative survey)
a. State: New Mexico
b. County: Eddy
c. BLM Field Office: Carlsbad
d. Nearest City or town: Carlsbad, NM
Location: T 21S, R 31E, Section 15: S½ SW¼ NE¼, NE¼ SW¼ NE¼, S½ SE¼ NW¼, E½ SW¼ NW¼, NE¼ SW¼ NW¼
Section 16: N½ SE¼ NE¼, N½ SW¼ NE¼, N½ SE¼ NW¼, N½ SW¼ NW¼
Well Pad Footages: N/A
f. 7.5' Map Name(s)and Code Number(s): Livingston Ridge, NM Provisional Edition 1985 (32103-D7)
g. Area
Block: Impact: 100 ft by 100 ft
Surveyed: 200 ft by 200 ft
Linear: Impact: 8,577.64 ft by 20 ft
Surveyed: 9,282.45 ft by 100 ft</td></tr>
<tr><td colspan="3">14. a. Records Search
Location: Bureau of Land Management – Carlsbad Field Office and the Archaeological Records Management System (ARMS) via modem
Date: January 29, 2003 by Natalie Allen
List by LA # all sites within .25 miles of the project (those sites within 500' are to be shown on the project map): No previously recorded archaeological sites are within 0.25 miles of the project area.</td></tr>
</table>

b. Description of Undertaking (client's activities): Westinghouse TRU Solutions, LLC plans on drilling a water monitoring well. The pad for the well will be 100 ft by 100 ft, yet an additional 50 ft on each side, totaling a 200 ft by 200 ft area was surveyed to ensure the protection of cultural resources. As originally staked, an access road for the well began at Louis Witlock Road and extended approximately 8450 ft west to the proposed location. Ron Richardson, with Westinghouse TRU Solutions, LLC requested Theresa Straight, an archaeologist with Mesa Field Services, to survey and flag a reroute around a fence to limit the amount of gates that need to be installed. The reroute totaled 832.45 ft long. The impact corridor for the access road and reroute is 20 ft wide, yet a 100 ft wide corridor was surveyed to ensure the protection of cultural resources. The project totaled 21.31 acres, of which 11.7 acres is on New Mexico State land and 9.61 acres is on BLM-CFO land.

c. Environmental Setting (NRCS soil designation, vegetative community, etc.): The project is located approximately 25 miles east of Carlsbad on a plain with a slope to the west. The soils vary from shallow with caliche gravels to deep brown sand wind worked into dunes 1 to 2 m high. They are of the Kermit-Berino and Simona-Pajarito associations as defined by the Soil Conservation Service of the U.S. Department of Agriculture. Project elevations range from 3,505 ft to 3,610 ft above mean sea level. Local vegetation is characteristic of Chihuahuan Desert Scrub and includes mesquite, grasses, pencil cholla, yucca, and prickly pear. Due to this vegetative cover, ground surface visibility ranged from 50 to 80 percent.

d. Field Methods

Transect Intervals: 15 m
Crew Size: 1
Time in Field: 3 hours
Collections: None

15. Cultural Resource Findings: Five isolated manifestations (IMs) were encountered and recorded during the survey.

Identification and Description (location shown on project map): IM 1 consists of a gray quartzite uniface with a variable edge angle, size 8 (Zone 13: E 616030/ N 3594144).

IM 2 consists of a single piece of burned caliche, size 4. A trowel test conducted was negative (Zone 13: E 615807/ N 3594130).

IM 3 consists of one pink chert flake with a crushed platform and no cortex, size 2 (Zone 13: E 615239/ N 3594183).

IM 4 consists of two pieces of burned caliche, both size 4. A trowel test was negative (Zone 13: E 613757/ N 3594276).

IM 5 consists of three pieces of burned caliche in a 1 m area ranging from size 10 to 20. Three trowel tests conducted were negative (Zone 13: E 614265/ N 3594253).

16. Management Summary (recommendations): Because no significant cultural material was encountered archaeological clearance is recommended for the well pad and access road as staked. If additional cultural material is encountered during construction activities, work at that location should stop and archaeologists at the BLM-CFO should be notified.

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

Responsible Archaeologist:
Signature______________________________________**Date**____________________

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

Survey for the SNL-1 Access Road and Water Monitor Well Location

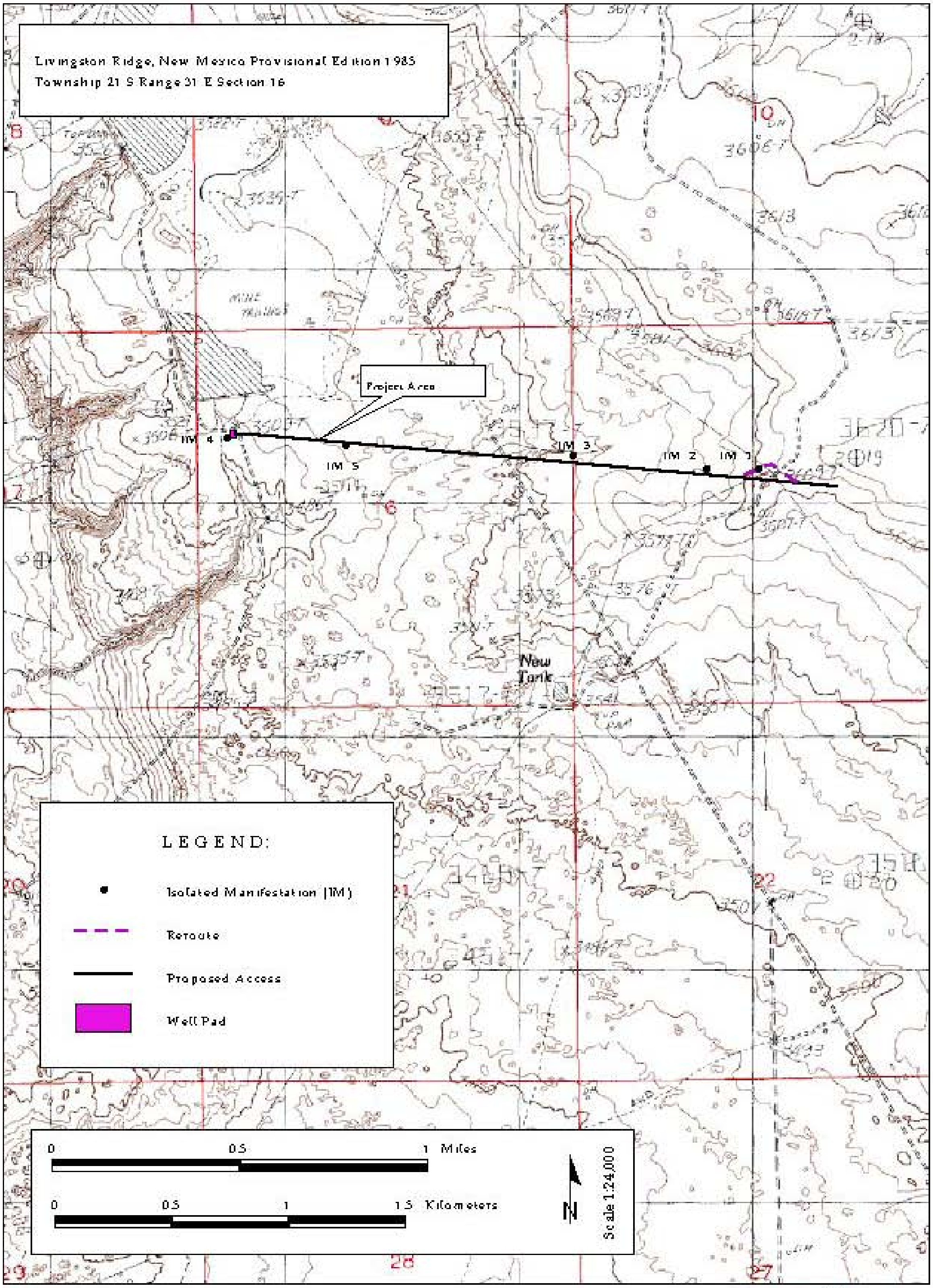


Figure 1. Project Area Map — *Mesa Field Services*

Appendix G
Photograph Logs

Digital photographs were taken of the cores from SNL-1. 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). Most of 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-1_Core001.jpg	3-29-04	SNL-1 drillpad; T21S, R31E, sec 16	Close-up photo of Forty-niner Mbr core, 462.0-463.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-1_Core002.jpg	3-29-04	SNL-1 drillpad; T21S, R31E, sec 16	Close-up photo of Forty-niner Mbr core, 462.8-464.2 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-1_Core003.jpg	3-29-04	SNL-1 drillpad; T21S, R31E, sec 16	Close-up photo of Forty-niner/Magenta Dolomite Mbrs core, 463.8-465.2 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-1_Core004.jpg	3-29-04	SNL-1 drillpad; T21S, R31E, sec 16	Close-up photo of Magenta Dolomite Mbr core, 464.9-466.2 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-1_Core005.jpg	3-29-04	SNL-1 drillpad; T21S, R31E, sec 16	Close-up photo of Magenta Dolomite Mbr core, 465.9-467.2 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-1_Core006.jpg	3-29-04	SNL-1 drillpad; T21S, R31E, sec 16	Close-up photo of Magenta Dolomite Mbr core, 466.9-468.2 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-1_Core007.jpg	3-29-04	SNL-1 drillpad; T21S, R31E, sec 16	Close-up photo of Magenta Doloimite Mbr core, 467.9-469.2 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-1_Core008.jpg	3-29-04	SNL-1 drillpad; T21S, R31E, sec 16	Close-up photo of Magenta Dolomite Mbr core, 468.9-470.3 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-1_Core009.jpg	3-29-04	SNL-1 drillpad; T21S, R31E, sec 16	Close-up photo of Magenta Dolomite Mbr core, 469.9-471.2 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-1_Core010.jpg	3-29-04	SNL-1 drillpad; T21S, R31E, sec 16	Close-up photo of Magenta Dolomite Mbr core, 470.9-472.2 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-1_Core011.jpg	3-29-04	SNL-1 drillpad; T21S, R31E, sec 16	Close-up photo of Magenta Dolomite Mbr core, 471.8-473.2 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-1_Core012.jpg	3-29-04	SNL-1 drillpad; T21S, R31E, sec 16	Close-up photo of Magenta Dolomite Mbr core, 472.9-473.6 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-1_Core013.jpg	3-29-04	SNL-1 drillpad; T21S, R31E, sec 16	Close-up photo of Magenta Dolomite Mbr core, 473.6-474.6 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-1_Core014.jpg	3-29-04	SNL-1 drillpad; T21S, R31E, sec 16	Close-up photo of Magenta Dolomite Mbr core, 473.9-475.2 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-1_Core015.jpg	3-29-04	SNL-1 drillpad; T21S, R31E, sec 16	Close-up photo of Magenta Dolomite Mbr core, 474.9-476.3 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-1_Core016.jpg	3-29-04	SNL-1 drillpad; T21S, R31E, sec 16	Close-up photo of Magenta Dolomite Mbr core, 475.9-477.2 ft bgl, with markings, scale	DW Powers Consultant to WTS

Camera: Nikon CoolPix 5700 **Resolution**: 2560 x 1920 **Page 1 of 7**

Photograph Log Sheet

File	DATE	LOCATION	DESCRIPTION OF SUBJECT (includes individual/group names, direction, etc. as appropriate)	PHOTOGRAPHER (initials and dept.)
SNL-1_Core017.jpg	3-29-04	SNL-1 drillpad; T21S, R31E, sec 16	Close-up photo of Magenta Dolomite Mbr core, 476.9-478.2 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-1_Core018.jpg	3-29-04	SNL-1 drillpad; T21S, R31E, sec 16	Close-up photo of Magenta Dolomite Mbr core, 477.9-479.2 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-1_Core019.jpg	3-29-04	SNL-1 drillpad; T21S, R31E, sec 16	Close-up photo of Magenta Dolomite Mbr core, 478.9-480.3 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-1_Core020.jpg	3-29-04	SNL-1 drillpad; T21S, R31E, sec 16	Close-up photo of Magenta Dolomite Mbr core, 479.9-481.3 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-1_Core021.jpg	3-29-04	SNL-1 drillpad; T21S, R31E, sec 16	Close-up photo of Magenta Dolomite Mbr core, 480.9-482.3 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-1_Core022.jpg	3-29-04	SNL-1 drillpad; T21S, R31E, sec 16	Close-up photo of Magenta Dolomite Mbr core, 481.9-483.2 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-1_Core023.jpg	3-29-04	SNL-1 drillpad; T21S, R31E, sec 16	Close-up photo of Magenta Dolomite Mbr core, 482.8-484.2 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-1_Core024.jpg	3-29-04	SNL-1 drillpad; T21S, R31E, sec 16	Close-up photo of Magenta Dolomite Mbr core, 483.8-485.2 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-1_Core025.jpg	3-29-04	SNL-1 drillpad; T21S, R31E, sec 16	Close-up photo of Magenta Dolomite Mbr core, 484.8-486.2 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-1_Core026.jpg	3-29-04	SNL-1 drillpad; T21S, R31E, sec 16	Close-up photo of Magenta Dolomite Mbr core, 485.7-487.2 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-1_Core027.jpg	3-29-04	SNL-1 drillpad; T21S, R31E, sec 16	Close-up photo of Magenta Dolomite Mbr core, 486.8-488.3 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-1_Core028.jpg	3-29-04	SNL-1 drillpad; T21S, R31E, sec 16	Close-up photo of Magenta Dolomite Mbr core, 487.8-489.2 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-1_Core029.jpg	3-29-04	SNL-1 drillpad; T21S, R31E, sec 16	Close-up photo of Magenta Dolomite Mbr core, 488.8-490.3 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-1_Core030.jpg	3-29-04	SNL-1 drillpad; T21S, R31E, sec 16	Close-up photo of Magenta Dolomite Mbr core, 489.7-491.3 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-1_Core031.jpg	3-29-04	SNL-1 drillpad; T21S, R31E, sec 16	Close-up photo of Magenta Dolomite Mbr core, 490.7-492.0 ft bgl, with markings, scale (end of core run)	DW Powers Consultant to WTS
SNL-1_Core032.jpg	3-31-04	SNL-1 drillpad; T21S, R31E, sec 16	Close-up photo of Tamarisk Mbr core, 548.0-549.1 ft bgl, with markings, scale	DW Powers Consultant to WTS

Camera: Nikon CoolPix 5700 **Resolution**: 2560 x 1920 **Page 2 of 7**

Photograph Log Sheet

File	DATE	LOCATION	DESCRIPTION OF SUBJECT (includes individual/group names, direction, etc. as appropriate)	PHOTOGRAPHER (initials and dept.)
SNL-1_Core033.jpg	3-31-04	SNL-1 drillpad; T21S, R31E, sec 16	Close-up photo of Tamarisk Mbr core, 548.9-550.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-1_Core034.jpg	3-31-04	SNL-1 drillpad; T21S, R31E, sec 16	Close-up photo of Tamarisk Mbr core, 549.9-551.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-1_Core035.jpg	3-31-04	SNL-1 drillpad; T21S, R31E, sec 16	Close-up photo of Tamarisk Mbr core, 550.9-552.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-1_Core036.jpg	3-31-04	SNL-1 drillpad; T21S, R31E, sec 16	Close-up photo of Tamarisk Mbr core, 551.9-553.2 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-1_Core037.jpg	3-31-04	SNL-1 drillpad; T21S, R31E, sec 16	Close-up photo of Tamarisk Mbr core, 553.0-554.2 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-1_Core038.jpg	3-31-04	SNL-1 drillpad; T21S, R31E, sec 16	Close-up photo of Tamarisk Mbr core, 553.8-555.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-1_Core039.jpg	3-31-04	SNL-1 drillpad; T21S, R31E, sec 16	Close-up photo of Tamarisk Mbr core, 554.9-556.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-1_Core040.jpg	3-31-04	SNL-1 drillpad; T21S, R31E, sec 16	Close-up photo of Tamarisk Mbr core, 555.9-557.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-1_Core041.jpg	3-31-04	SNL-1 drillpad; T21S, R31E, sec 16	Close-up photo of Tamarisk Mbr core, 556.9-558.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-1_Core042.jpg	3-31-04	SNL-1 drillpad; T21S, R31E, sec 16	Close-up photo of Tamarisk Mbr core, 557.9-559.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-1_Core043.jpg	3-31-04	SNL-1 drillpad; T21S, R31E, sec 16	Close-up photo of Tamarisk Mbr core, 558.9-560.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-1_Core044.jpg	3-31-04	SNL-1 drillpad; T21S, R31E, sec 16	Close-up photo of Tamarisk Mbr core, 559.9-561.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-1_Core045.jpg	3-31-04	SNL-1 drillpad; T21S, R31E, sec 16	Close-up photo of Tamarisk Mbr core, 561.1-562.2 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-1_Core046.jpg	3-31-04	SNL-1 drillpad; T21S, R31E, sec 16	Close-up photo of Tamarisk Mbr core, 561.9-563.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-1_Core047.jpg	3-31-04	SNL-1 drillpad; T21S, R31E, sec 16	Close-up photo of Tamarisk Mbr core, 562.8-564.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-1_Core048.jpg	3-31-04	SNL-1 drillpad; T21S, R31E, sec 16	Close-up photo of Tamarisk Mbr core, 563.8-565.1 ft bgl, with markings, scale	DW Powers Consultant to WTS

Camera: Nikon CoolPix 5700 **Resolution**: 2560 x 1920

Photograph Log Sheet

File	DATE	LOCATION	DESCRIPTION OF SUBJECT (includes individual/group names, direction, etc. as appropriate)	PHOTOGRAPHER (initials and dept.)
SNL-1_Core049.jpg	3-31-04	SNL-1 drillpad; T21S, R31E, sec 16	Close-up photo of Tamarisk Mbr core, 564.8-566.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-1_Core050.jpg	3-31-04	SNL-1 drillpad; T21S, R31E, sec 16	Close-up photo of Tamarisk Mbr core, 565.8-567.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-1_Core051.jpg	3-31-04	SNL-1 drillpad; T21S, R31E, sec 16	Close-up photo of Tamarisk Mbr core, 566.9-568.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-1_Core052.jpg	3-31-04	SNL-1 drillpad; T21S, R31E, sec 16	Close-up photo of Tamarisk Mbr core, 567.9-569.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-1_Core053.jpg	3-31-04	SNL-1 drillpad; T21S, R31E, sec 16	Close-up photo of Tamarisk Mbr core, 568.9-570.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-1_Core054.jpg	3-31-04	SNL-1 drillpad; T21S, R31E, sec 16	Close-up photo of Tamarisk Mbr core, 569.9-571.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-1_Core055.jpg	3-31-04	SNL-1 drillpad; T21S, R31E, sec 16	Close-up photo of Tamarisk Mbr core, 570.9-572.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-1_Core056.jpg	3-31-04	SNL-1 drillpad; T21S, R31E, sec 16	Close-up photo of Tamarisk Mbr core, 571.9-573.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-1_Core057.jpg	3-31-04	SNL-1 drillpad; T21S, R31E, sec 16	Close-up photo of Tamarisk Mbr core, 572.9-574.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-1_Core058.jpg	3-31-04	SNL-1 drillpad; T21S, R31E, sec 16	Close-up photo of Tamarisk Mbr core, 573.9-575.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-1_Core059.jpg	3-31-04	SNL-1 drillpad; T21S, R31E, sec 16	Close-up photo of Tamarisk Mbr core, 574.9-576.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-1_Core060.jpg	3-31-04	SNL-1 drillpad; T21S, R31E, sec 16	Close-up photo of Tamarisk Mbr core, 575.9-577.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-1_Core061.jpg	3-31-04	SNL-1 drillpad; T21S, R31E, sec 16	Close-up photo of Tamarisk Mbr core, 576.9-578.0 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-1_Core062.jpg	3-31-04	SNL-1 drillpad; T21S, R31E, sec 16	Close-up photo of Tamarisk Mbr core, 578.0-579.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-1_Core063.jpg	3-31-04	SNL-1 drillpad; T21S, R31E, sec 16	Close-up photo of Tamarisk Mbr core, 578.9-580.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-1_Core064.jpg	3-31-04	SNL-1 drillpad; T21S, R31E, sec 16	Close-up photo of Tamarisk Mbr core, 579.9-581.1 ft bgl, with markings, scale	DW Powers Consultant to WTS

Camera: Nikon CoolPix 5700 **Resolution**: 2560 x 1920 **Page 4 of 7**

Photograph Log Sheet

File	DATE	LOCATION	DESCRIPTION OF SUBJECT (includes individual/group names, direction, etc. as appropriate)	PHOTOGRAPHER (initials and dept.)
SNL-1_Core065.jpg	3-31-04	SNL-1 drillpad; T21S, R31E, sec 16	Close-up photo of Tamarisk Mbr core, 580.9-582.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-1_Core066.jpg	3-31-04	SNL-1 drillpad; T21S, R31E, sec 16	Close-up photo of Tamarisk Mbr core, 581.9-583.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-1_Core067.jpg	3-31-04	SNL-1 drillpad; T21S, R31E, sec 16	Close-up photo of Tamarisk Mbr core, 582.9-584.2 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-1_Core068.jpg	3-31-04	SNL-1 drillpad; T21S, R31E, sec 16	Close-up photo of Tamarisk Mbr core, 584.1-585.5 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-1_Core069.jpg	3-31-04	SNL-1 drillpad; T21S, R31E, sec 16	Close-up photo of Tamarisk Mbr core, 585.5-586.3 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-1_Core070.jpg	3-31-04	SNL-1 drillpad; T21S, R31E, sec 16	Close-up photo of Tamarisk Mbr core, 585.9-587.2 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-1_Core071.jpg	3-31-04	SNL-1 drillpad; T21S, R31E, sec 16	Close-up photo of Tamarisk Mbr core, 586.9-588.2 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-1_Core072.jpg	3-31-04	SNL-1 drillpad; T21S, R31E, sec 16	Close-up photo of Tamarisk Mbr core, 587.9-589.2 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-1_Core073.jpg	3-31-04	SNL-1 drillpad; T21S, R31E, sec 16	Close-up photo of Tamarisk Mbr core, 588.9-590.2 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-1_Core074.jpg	3-31-04	SNL-1 drillpad; T21S, R31E, sec 16	Close-up photo of Tamarisk Mbr core, 589.9-591.2 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-1_Core075.jpg	3-31-04	SNL-1 drillpad; T21S, R31E, sec 16	Close-up photo of Tamarisk Mbr core, 590.9-592.2 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-1_Core076.jpg	3-31-04	SNL-1 drillpad; T21S, R31E, sec 16	Close-up photo of Tamarisk Mbr core, 591.9-593.2 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-1_Core077.jpg	3-31-04	SNL-1 drillpad; T21S, R31E, sec 16	Close-up photo of Tamarisk Mbr core, 592.9-594.2 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-1_Core078.jpg	3-31-04	SNL-1 drillpad; T21S, R31E, sec 16	Close-up photo of Tamarisk Mbr core, 593.9-595.2 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-1_Core079.jpg	3-31-04	SNL-1 drillpad; T21S, R31E, sec 16	Close-up photo of Tamarisk Mbr core, 594.9-596.2 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-1_Core080.jpg	3-31-04	SNL-1 drillpad; T21S, R31E, sec 16	Close-up photo of Tamarisk / Culebra Dolomite Mbrs core, 595.9-597.2 ft bgl, with markings, scale	DW Powers Consultant to WTS

Camera: Nikon CoolPix 5700 **Resolution**: 2560 x 1920 **Page 5 of 7**

Photograph Log Sheet

File	DATE	LOCATION	DESCRIPTION OF SUBJECT (includes individual/group names, direction, etc. as appropriate)	PHOTOGRAPHER (initials and dept.)
SNL-1_Core081.jpg	3-31-04	SNL-1 drillpad; T21S, R31E, sec 16	Close-up photo of Culebra Dolomite Mbr core, 596.9-598.2 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-1_Core082.jpg	3-31-04	SNL-1 drillpad; T21S, R31E, sec 16	Close-up photo of Culebra Dolomite Mbr core, 597.9-599.2 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-1_Core083.jpg	3-31-04	SNL-1 drillpad; T21S, R31E, sec 16	Close-up photo of Culebra Dolomite Mbr core, 598.9-600.2 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-1_Core084.jpg	3-31-04	SNL-1 drillpad; T21S, R31E, sec 16	Close-up photo of Culebra Dolomite Mbr core, 599.9-600.5 ft bgl, with markings, scale (lost 600.5-601.0 during drilling)	DW Powers Consultant to WTS
SNL-1_Core085.jpg	4-1-04	SNL-1 drillpad; T21S, R31E, sec 16	Close-up photo of Culebra Dolomite Mbr core, 601.0-602.2 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-1_Core086.jpg	4-1-04	SNL-1 drillpad; T21S, R31E, sec 16	Close-up photo of Culebra Dolomite Mbr core, 601.9-603.2 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-1_Core087.jpg	4-1-04	SNL-1 drillpad; T21S, R31E, sec 16	Close-up photo of Culebra Dolomite Mbr core, 602.9-604.2 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-1_Core088.jpg	4-1-04	SNL-1 drillpad; T21S, R31E, sec 16	Close-up photo of Culebra Dolomite Mbr core, 603.9-605.2 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-1_Core089.jpg	4-1-04	SNL-1 drillpad; T21S, R31E, sec 16	Close-up photo of Culebra Dolomite Mbr core, 604.9-606.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-1_Core090.jpg	4-1-04	SNL-1 drillpad; T21S, R31E, sec 16	Close-up photo of Culebra Dolomite Mbr core, 605.9-607.2 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-1_Core091.jpg	4-1-04	SNL-1 drillpad; T21S, R31E, sec 16	Close-up photo of Culebra Dolomite Mbr core, 606.9-607.5 ft bgl, with markings, scale (photo cropped)	DW Powers Consultant to WTS
SNL-1_Core092.jpg	4-1-04	SNL-1 drillpad; T21S, R31E, sec 16	Close-up photo of Culebra Dolomite Mbr core, 620.9-621.6 ft bgl, with markings, scale (core above lost during drilling)	DW Powers Consultant to WTS
SNL-1_Core093.jpg	4-1-04	SNL-1 drillpad; T21S, R31E, sec 16	Close-up photo of Culebra Dolomite Mbr core, 622.0-623.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-1_Core094.jpg	4-1-04	SNL-1 drillpad; T21S, R31E, sec 16	Close-up photo of Culebra Dolomite Mbr core, 622.9-624.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-1_Core095.jpg	4-1-04	SNL-1 drillpad; T21S, R31E, sec 16	Close-up photo of Culebra Dolomite Mbr core, 623.9-625.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-1_Core096.jpg	4-1-04	SNL-1 drillpad; T21S, R31E, sec 16	Close-up photo of Culebra Dolomite/Los Medaños Mbrs core, 624.9-626.1 ft bgl, with markings, scale	DW Powers Consultant to WTS

Camera: Nikon CoolPix 5700 **Resolution**: 2560 x 1920 **Page** 6 **of** 7

Photograph Log Sheet

File	DATE	LOCATION	DESCRIPTION OF SUBJECT (includes individual/group names, direction, etc. as appropriate)	PHOTOGRAPHER (initials and dept.)
SNL-1_Core097.jpg	4-1-04	SNL-1 drillpad; T21S, R31E, sec 16	Close-up photo of Los Medaños Mbr core, 525.9-527.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-1_Core098.jpg	4-1-04	SNL-1 drillpad; T21S, R31E, sec 16	Close-up photo of Los Medaños Mbr core, 526.9-528.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-1_Core099.jpg	4-1-04	SNL-1 drillpad; T21S, R31E, sec 16	Close-up photo of Los Medaños Mbr core, 527.9-529.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-1_Core100.jpg	4-1-04	SNL-1 drillpad; T21S, R31E, sec 16	Close-up photo of Los Medaños Mbr core, 528.9-530.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-1_Core101.jpg	4-1-04	SNL-1 drillpad; T21S, R31E, sec 16	Close-up photo of Los Medaños Mbr core, 529.9-531.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-1_Core102.jpg	4-1-04	SNL-1 drillpad; T21S, R31E, sec 16	Close-up photo of Los Medaños Mbr core, 530.9-532.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-1_Core103.jpg	4-1-04	SNL-1 drillpad; T21S, R31E, sec 16	Close-up photo of Los Medaños Mbr core, 531.9-533.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-1_Core104.jpg	4-1-04	SNL-1 drillpad; T21S, R31E, sec 16	Close-up photo of Los Medaños Mbr core, 532.9-534.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-1_Core105.jpg	4-1-04	SNL-1 drillpad; T21S, R31E, sec 16	Close-up photo of Los Medaños Mbr core, 533.9-535.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-1_Core106.jpg	4-1-04	SNL-1 drillpad; T21S, R31E, sec 16	Close-up photo of Los Medaños Mbr core, 534.9-536.2 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-1_Core107.jpg	4-1-04	SNL-1 drillpad; T21S, R31E, sec 16	Close-up photo of Los Medaños Mbr core, 535.8-536.5 ft bgl, with markings, scale	DW Powers Consultant to WTS

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