DOE/WIPP 03-3290

Basic Data Report
For Drillhole SNL-2 (C-2948)
(Waste Isolation Pilot Plant)

October 2003

DEPARTMENT OF ENERGY
UNITED STATES OF AMERICA

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For Drillhole SNL-2 (C-2948)
(Waste Isolation Pilot Plant)

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October 2003

West Texas Water Well Service Rig #15 (Gardner-Denver 1500) on-site at SNL-2, viewed toward the west. The drill rig is set up for drilling with compressed air and foam, which is discharging into the mud pit to the left. IMC Kalium potash mine surface facilities and tailings are visible near the horizon (left center) over the front-end loader.

EXECUTIVE SUMMARY

SNL-2 (permitted by the New Mexico State Engineer as C-2948) 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 part of the Salado near Livingston Ridge. SNL-2 is located in the northwest quarter of section 12, T22S, R30E, in eastern Eddy County, New Mexico. SNL-2 was drilled to a total depth of 614 ft below the ground level. Below surface dune sand and the Berino soil, SNL-2 encountered, in order, the Mescalero caliche, Gatuña, Dewey Lake, Rustler, and uppermost Salado 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 Los Medaños Members and into the uppermost Salado Formation. Hole stability problems below the Culebra led to a decision not to attempt further drilling to acquire additional Salado geological data. Geophysical logs were acquired from the open hole to below the Culebra, and the drillhole was successfully completed with a screened interval open across the Culebra.

At SNL-2, the uppermost Salado cores display several depositional cycles as well as displacive halite crystals in clastic-rich units near the top. There is no indication of thinning of the upper Salado due to postdepositional dissolution, and this is consistent with predrilling expectations. The Los Medaños has a thickness and stratigraphic sequence very similar to that found at the center of the Waste Isolation Pilot Plant (WIPP) site, but much of the lower Los Medaños porosity has been filled by halite cement. Earlier studies suggested that the western margin for the occurrence of halite in this unit was northeast of the SNL-2 location. The Culebra Dolomite is about average in thickness (25 ft), and recovered core shows bedding and porosity similar to that across much of the western part of the WIPP site. Core was lost from part of the lower-middle Culebra, which is usually the most porous and transmissive part of the unit. The Tamarisk has a normal stratigraphic sequence and thickness, and the mudstone unit shows typical reddish-brown sandy claystone overlain by gray and reddish-brown siltstone. Intraclasts of siltstone are preserved, as are angular clasts or fragments of gypsum. The Magenta Dolomite is about 23 ft thick and shows typical laminar to wavy bedding, some ripples, and algal stromatolites. The Forty-niner is represented by a typical sulfate–mudstone–sulfate sequence. The Dewey Lake was partially eroded, and the Santa Rosa completely removed, prior to deposition of the Gatuña. Cuttings and geophysical logs indicate that the sulfate–carbonate cement transition in the Dewey Lake is about 184 ft below ground level at SNL-2, which is lower stratigraphically than the cement boundary near the center of the WIPP site. The Gatuña is more than 100 ft thick at SNL-2, and the thickness is consistent with observed Gatuña outcrops at nearby Livingston Ridge.

No water was encountered in the Gatuña or Dewey Lake. There was little indication of water in the Magenta during drilling. Water flowed into the hole from the Culebra during drilling and water levels from the open hole prior to reaming and casing rose to near the base of the Magenta. There was no indication of fluid inflow at the Rustler–Salado contact during drilling or from cores.

Most of the open drillhole below the Culebra was cemented before reaming.The drillhole was reamed to a diameter of 12.25 inches through the Culebra. Fiberglass reinforced plastic casing (4.83 inches outside diameter) was placed in the hole, with a screen interval across the Culebra Dolomite. The annulus was filled with 8/16 Brady sand to just above the Culebra, and bentonite was placed on the sand to separate the Culebra from the Tamarisk mudstone. The annulus above the bentonite was cemented to the surface. The well was developed over parts of two days by repeated pumping and recovery periods, with pumping rates ranging from about ½ to 6 gallons per minute. Water levels measured since additional well development are about 3,064 ft above mean sea level.

Table of Contents

List of Figures and Tables

In keeping with practice at the WIPP site, the basic data for SNL-2 are reported in the inch-pound, or English, system; metric equivalents are given in one figure. The following conversion factors for metric equivalents may be useful:

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

1.0 INTRODUCTION

SNL-2 was drilled in the northwest quarter of Section 12, T22S, R30E, in eastern Eddy County, New Mexico (Fig. 1-1). It is located 574 ft from the north line (fnl) and 859 ft from the west line (fwl) of the section (Fig. 1-2). This location places the drillhole east of the Livingston Ridge escarpment among oil wells of the Cabin Lake field. SNL-2 will be used to test hydraulic properties and to monitor groundwater levels of the Culebra Dolomite Member of the Permian Rustler Formation for the Waste Isolation Pilot Plant (WIPP).

SNL-2 was permitted by the New Mexico State Engineer as C-2948. [Official correspondence regarding permitting and regulatory information must reference this permit number.] In the plan describing the integrated groundwater hydrology program (Sandia National Laboratories, 2003), SNL-2 is also co-designated WTS-1 because the location also satisfies needs for long-term monitoring of water levels and flow rate and direction in the Culebra Dolomite for Resource Conservation and Recovery Act permit compliance; this program is under the management of Washington TRU Solutions LLC (WTS).

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-2

SNL-2 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-2 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. Department of Energy, 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). SNL-2 was located to test Culebra hydraulic properties near the upper Salado dissolution margin as well as confirming the geological conditions used to estimate Culebra hydraulic properties (Sandia National Laboratories, 2003; Powers, 2002a; Powers and others, 2003).

The drillhole is to (Sandia National Laboratories, 2003, p. 40; see also Appendix A):

1. Determine if dissolution of the upper Salado is extending beneath Livingston Ridge at this location;
2. Determine whether hydraulic properties are consistent with dissolution propagating from

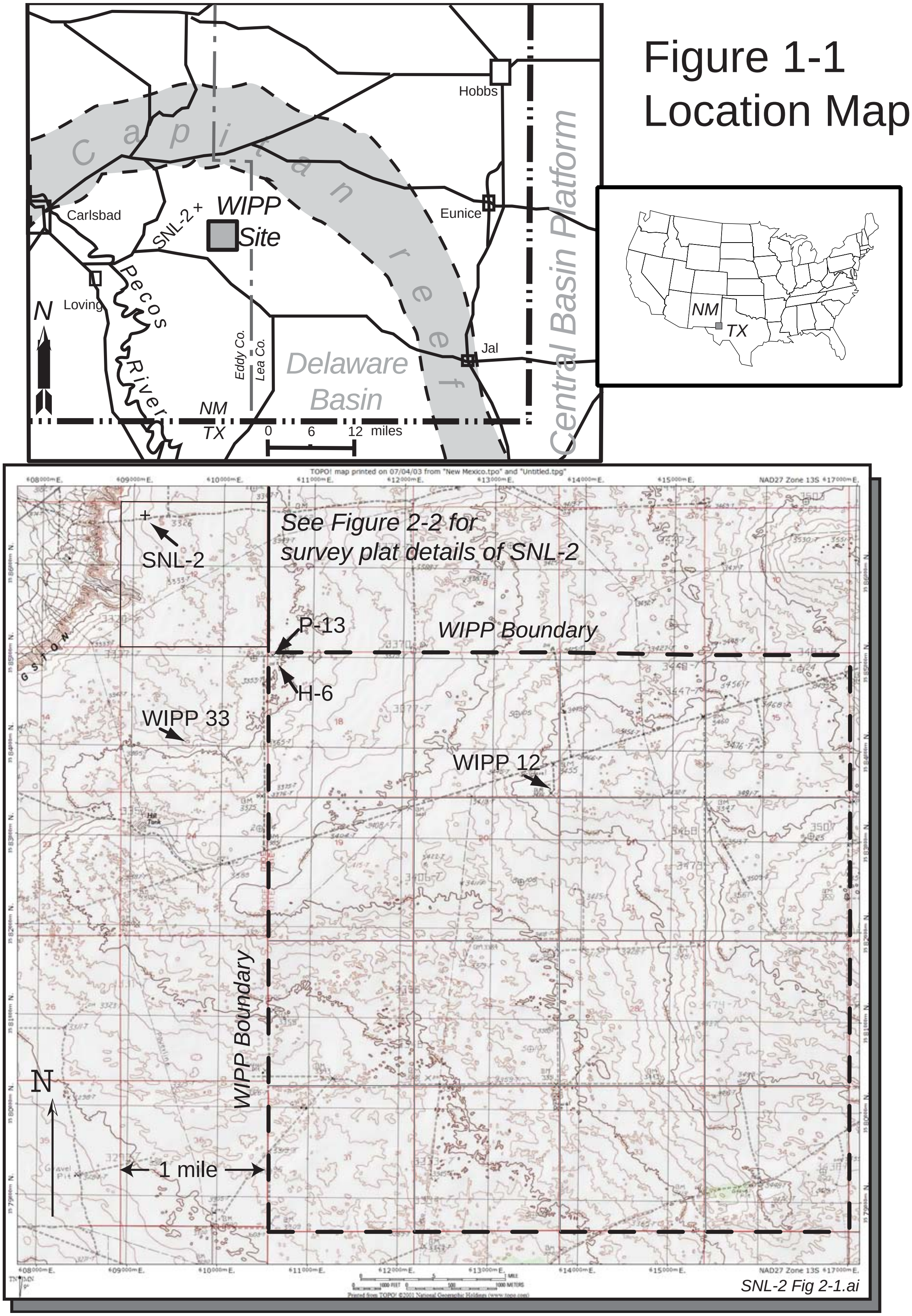


Figure 1-1
Location Map

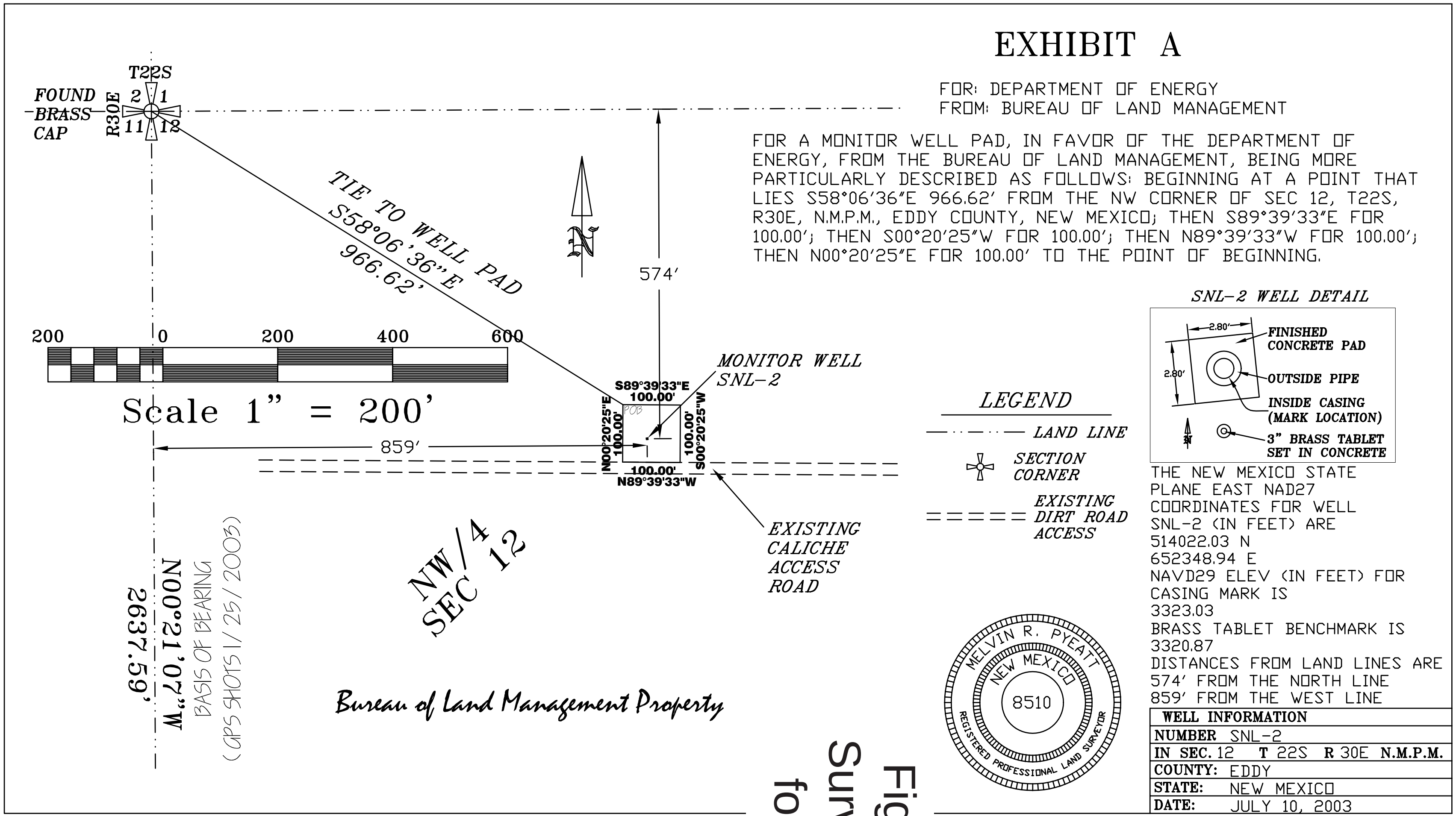


EXHIBIT A

FOR: DEPARTMENT OF ENERGY
FROM: BUREAU OF LAND MANAGEMENT

FOR A MONITOR WELL PAD, IN FAVOR OF THE DEPARTMENT OF ENERGY, FROM THE BUREAU OF LAND MANAGEMENT, BEING MORE PARTICULARLY DESCRIBED AS FOLLOWS: BEGINNING AT A POINT THAT LIES S58°06'36"E 966.62' FROM THE NW CORNER OF SEC 12, T22S, R30E, N.M.P.M., EDDY COUNTY, NEW MEXICO; THEN S89°39'33"E FOR 100.00'; THEN S00°20'25"W FOR 100.00'; THEN N89°39'33"W FOR 100.00'; THEN N00°20'25"E FOR 100.00' TO THE POINT OF BEGINNING.

THE NEW MEXICO STATE PLANE EAST NAD27 COORDINATES FOR WELL SNL-2 (IN FEET) ARE
514022.03 N
652348.94 E

NAVD29 ELEV (IN FEET) FOR CASING MARK IS
3323.03

BRASS TABLET BENCHMARK IS
3320.87

DISTANCES FROM LAND LINES ARE
574' FROM THE NORTH LINE
859' FROM THE WEST LINE

WELL INFORMATION	
NUMBER	SNL-2
IN SEC. 12	T 22S R 30E N.M.P.M.
COUNTY:	EDDY
STATE:	NEW MEXICO
DATE:	JULY 10, 2003

MELVIN R. PYEATT 8510

Figure 1-2
Survey Plat
for SNL-2

Nash Draw to the southeast toward the WIPP site;

3. Determine how well-connected the Culebra and Magenta are upgradient of the WIPP site on the edge of Nash Draw;
4. Determine if flow at this location is toward, or away from, the WIPP site; and
5. Provide a monitoring location for a large-scale (multipad) pumping test (centered at SNL-5) to provide transient data for calibration of the Culebra model north of the WIPP site.

1.3 SNL-2 Drilling and Completion

The basic information about drilling and completion of SNL-2 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-2 was rotary drilled and cored to a total depth of 614 ft bgl (Fig. 1-3). As the drillhole progressed, circulating fluids were successively changed from air to fresh-water mist with foam to brine with foam to brine with surfactant. The changes reflect needs for determining geological and hydrological conditions in the drillhole as well as maintaining control of drillhole conditions. Drillhole fill in the lower Rustler led to a decision not to deepen the drillhole to marker beds in the upper Salado; cores of the uppermost Salado had adequately answered geological questions of Salado halite dissolution at SNL-2.

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-2 was cased with fiberglass reinforced plastic (FRP) casing rather than steel to provide longer utility of the well for monitoring and testing. Steel-cased wells at WIPP are expected to be plugged and abandoned and, where necessary, replaced with wells completed similar to SNL-2 (Sandia National Laboratories, 2003).

SNL-2 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, on the SNL-2 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-2 (Fig. 1-4) (Appendices D and E). The drillhole was cemented back to a level below the Culebra to protect the lower Rustler from circulation of Culebra water (Fig. 1-4). The bottom of the Culebra screen interval was placed at 480 ft to remain above the claystone below the Culebra and avoid possible plugging of the lowermost slots (Fig. 1-4). The top of the screen is above the top of the Culebra. The top of the sand/gravel pack (8/16 silica sand) is below the level of the mudstone in the Tamarisk to prevent connection to the Culebra. The annulus above the sand/gravel pack was cemented to the surface. A final caliper log (Fig. 1-3) after the drillhole was reamed to 12.25 inches and before the casing was placed shows drillhole enlargement in the Gatuña, through the Dewey Lake, the Forty-niner mudstone, the Tamarisk mudstone, and the upper Los Medaños. Except for the upper Los Medaños, 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 benchmark is an accessible reference point for future measurements if the well configuration is changed. Geophysical logs and depths for FRP casing, screen, and fill in the annulus are measured from the top of the connector on the steel surface conductor casing. The top of FRP casing was cut off 2 ft above this point before the outer protective steel casing was threaded to the connector on the steel surface conductor casing. The cement pad was poured around the surface conductor casing and connector.

1.4 Other Background

SNL-2 was drilled and completed by the West Texas Water Well Service, 3410 Mankins, Odessa, Texas, under contract from WTS. Coring was done by John W. 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. Mike Stapleton 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-2 and disposed of by Controlled Recovery, Inc., Hobbs, NM, 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-2 were photographed with digital cameras, 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 Rodney Dutton (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. Ray Federwisch (Geophysical Logging Services) provided the printed and electronic files that were used to develop Figure 2-1. Chris Mahoney checked certain files and figures and provided data files for sections. Vivian Allen (L&M) provided useful editorial guidance.

Table 1-1. Summary of Drilling and Well Completion Records for Hydrologic Drillhole SNL-2 (C-2948)

LOCATION: Northwest ¼, Section 12, Township 22 South (T22S), Range 30 East (R30E)

SURFACE COORDINATES: The well is located 574 ft from the north line (fnl) and 859 ft from the west line (fwl) of Section 12. The New Mexico State Plane (NAD 27) horizontal coordinates in feet are 514022.03 North, 652348.94 East (Fig. 1-2 shows the survey plat). UTM horizontal coordinates (NAD27, Zone 13) in meters were calculated for SNL-2 using Corpscon for Windows (v. 5.11.08): 609112.98 East, 3586528.88 North. Figure 1-1 shows UTM coordinates on a 1000-m grid.

ELEVATION: All depths used in geological and geophysical data here are reported below ground level (bgl), which is taken as 3321 ft above mean sea level (amsl), the rounded value for the brass tablet benchmark (3320.87 ft amsl) adjacent to the cement well pad. The primary datum for the completed well is 3323.03 ft amsl (NAVD 29) for a mark on the top of the casing inside the protective well pipe. Figures 1-3 and 1-4 show the as-built configuration of SNL-2.

DRILLING RECORD:

Dates: Began drilling April 28, 2003; drillhole reamed to completion depth (489 ft) on May 14, 2003. Final geophysical logging was conducted on May 14, 2003. Drillhole was prepared for casing, and was cased and cemented May 15, 2003. Rig was moved off the drillpad May 16, 2003. SNL-2 well development began May 20, 2003; the pump was removed on May 24, 2003.

Circulation Fluid: SNL-2 was drilled to 90.5 ft bgl with circulating air; the upper 30 ft were reamed with air, and the surface conductor casing was cemented. Because of drillhole instability below the surface conductor casing, the hole was drilled and cored to 489.4 ft bgl (below Culebra) using Baroid Quik-Foam® and fresh water mist driven by compressed air. From 489.4 ft bgl to total depth (614 ft bgl), the drillhole was cored using Baroid Quik-Foam® with brine mist driven by compressed air. Hole conditions deteriorated as the cored interval was being reamed to 7.875 inches using brine mist and Baroid Quik-Foam®. After geophysical logging and plugging the lower part of the drillhole, SNL-2 was reamed to a final diameter (12.25 inches) to 489 ft using circulating brine with Flowzan® biopolymer (MSDS# 463650) in a portable mud pit.

Cored Intervals: 4.0-inch core was taken through these intervals (depths from drilling data):
328.0-373 ft bgl: lower Forty-niner, Magenta Dolomite, and upper Tamarisk Members
420.0-614.0 ft bgl: lower Tamarisk, Culebra Dolomite, and Los Medaños Members; and upper Salado Formation

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-2 (C-2948), continued.

Drillhole Record:

Size (inches)	From (ft bgl)	To (ft bgl)
18	0	30
12.25	30	489
6.5	489	614

Note: The lower part of drillhole filled in partially after it was cored; the drillhole was then cemented back to above 510 ft bgl.

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	452.1
4.83	4.33	3.20 FRP screen	452.1	480.0
4.83	4.33	3.20 FRP blank	480.0	487.2

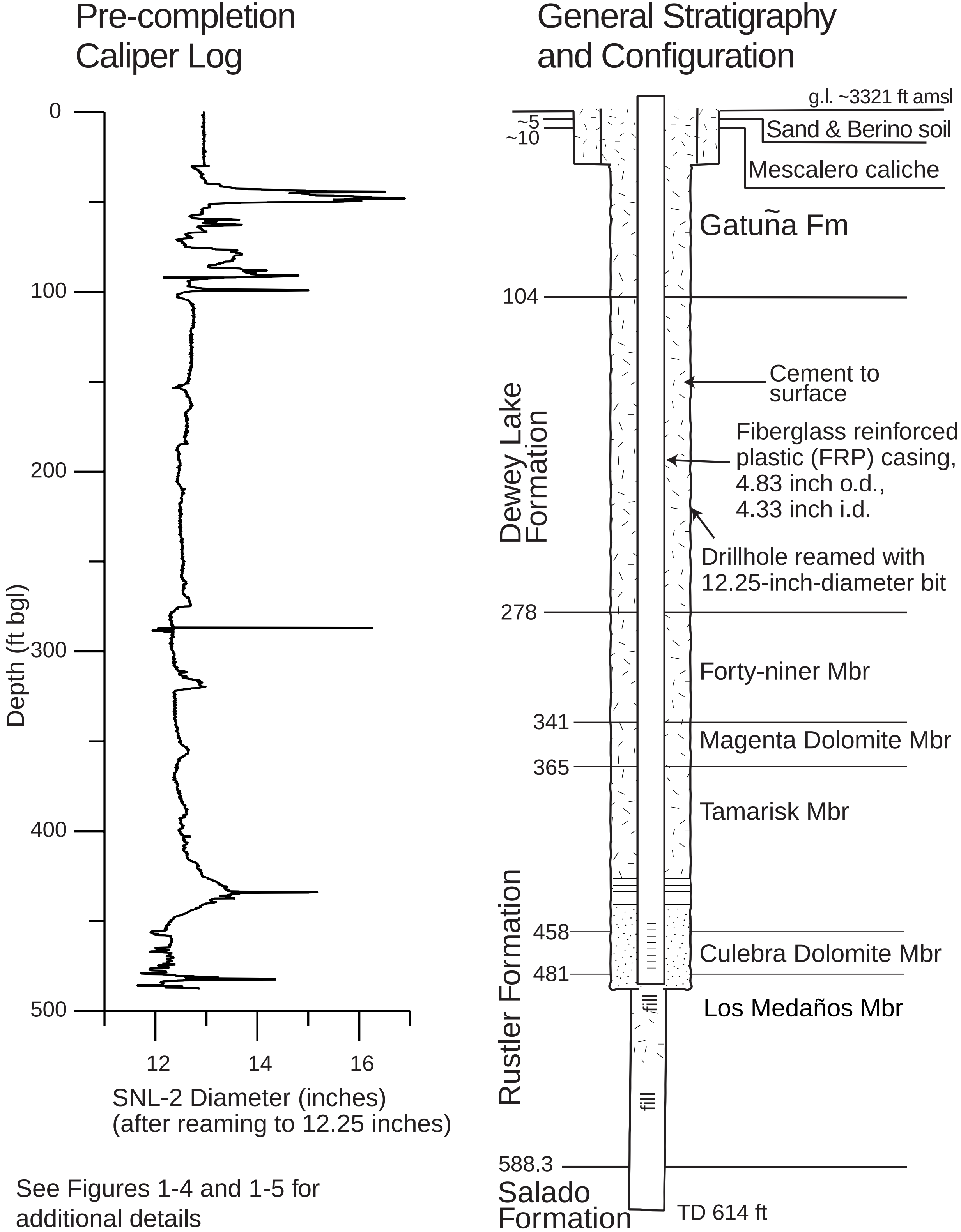
*Top of the casing connector is the reference for depth denoted below ground level (bgl). The FRP extends 2 ft (-2) above the steel casing connector near ground level..
**FRP: fiberglass reinforced plastic

Coring Record:

Core Run No.	Depth Interval (ft) From	To	Interval (ft) Cored	Recovered	Recovered %
1	328	358	30	29.2	97.33%
2	358	373	15	15.1	100.67%
3	420	449.6	29.6	28.6	96.62%
4	449.6	472.2	22.6	15.6	69.03%
5	472.2	486.1	13.9	9	64.75%
6	486.1	527.1	41	22.4	54.63%
7	527.1	542.9	15.8	14.8	93.67%
8	542.9	577.9	35	34.5	98.57%
9	577.9	584.4	6.5	6.5	100.00%
10	584.4	613.4	29	30.4	104.83%
		Totals	238.4	206.1	86.45%

Note: Marked core depths (e.g., Appendix C) vary slightly from core interval depths partly due to differing recoveries from intervals and mismark of 472.2 ft core depth as 471.2 ft.

Figure 1-3
SNL-2 As-Built Diagram



See Figures 1-4 and 1-5 for additional details

Figure 1-4
SNL-2 Completion and Monitoring Configuration (5/15/03)

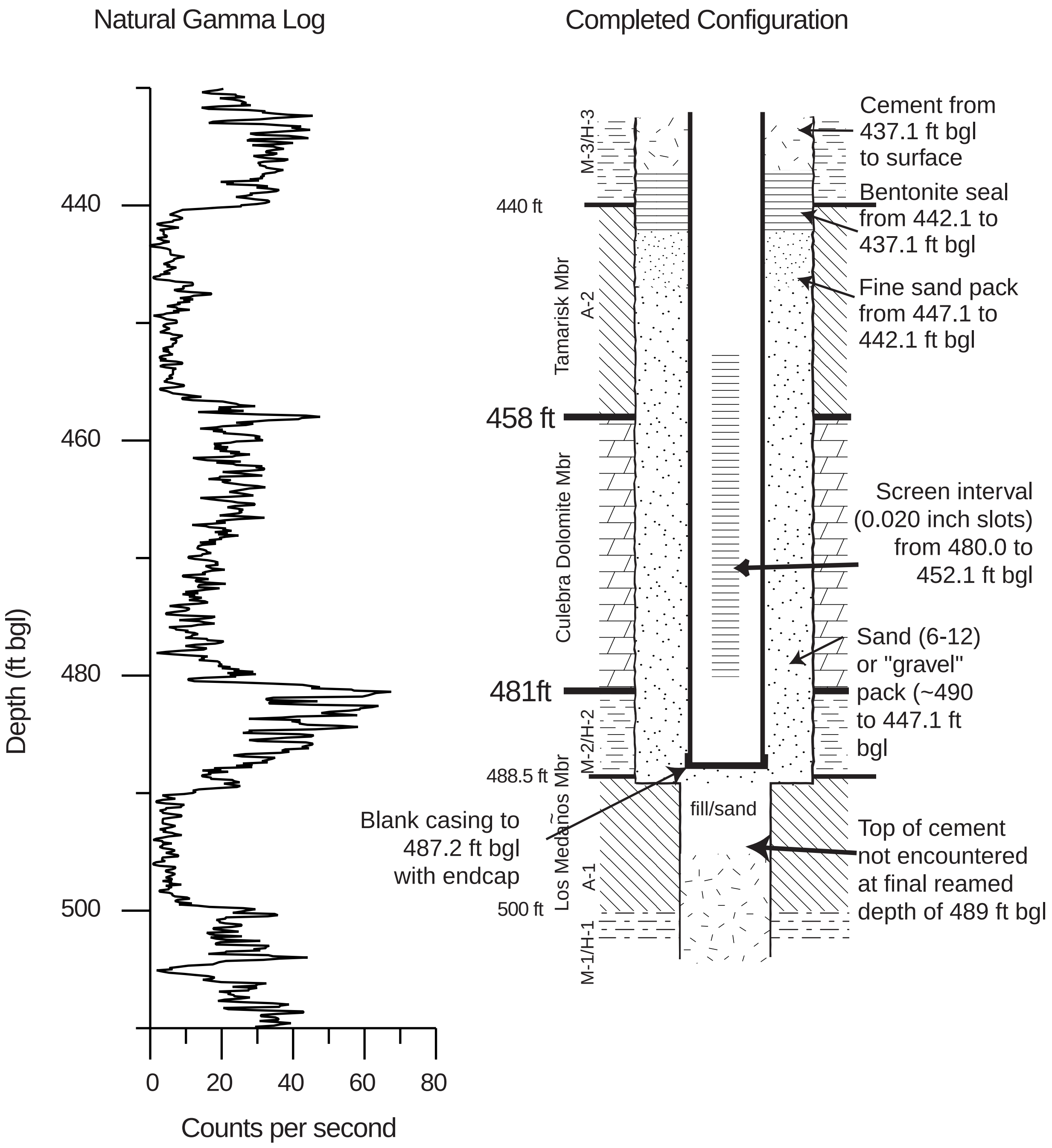
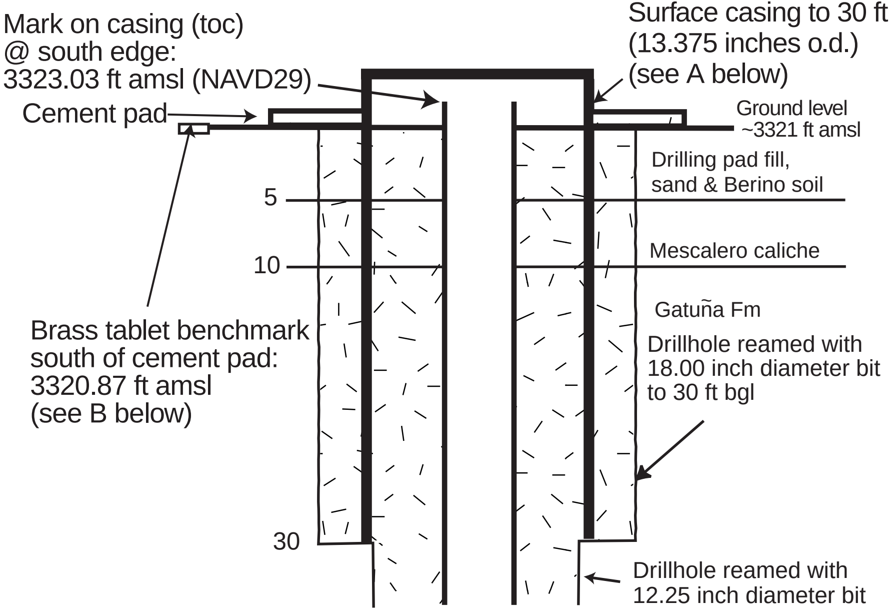
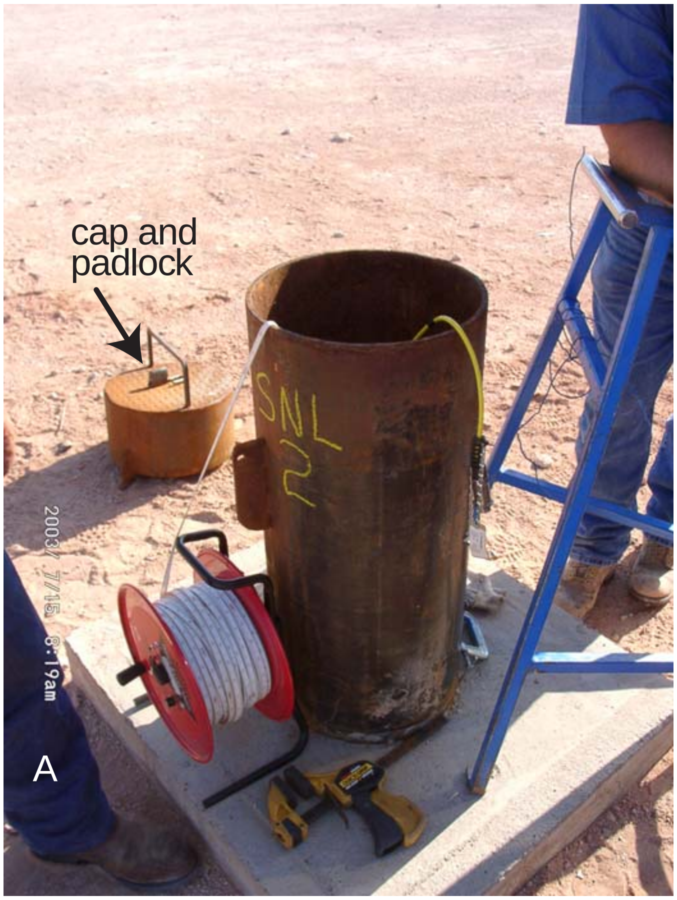


Figure 1-5
SNL-2 Surface Configuration and Elevations (7/15/03)





A - Surface casing for SNL-2 with cap and padlock (open for work to prepare well for water level monitoring).

B - Detail of brass tablet benchmark on south side of SNL-2 cement pad.

2.0 GEOLOGICAL DATA

2.1 General Geological Background

The geology and hydrology of formations at the WIPP site and surroundings have been intensively investigated since 1975, and the information and interpretations have been reported in numerous documents. The most thorough compilation is certainly the Compliance Certification Application (CCA) submitted in 1996 by the DOE to the EPA (U.S. Department of Energy, 1996). Some salient features of the broader geological history, as well as more recent work on the geohydrology of the Rustler (e.g., Holt and Yarbrough , 2002, Powers, 2002a; Powers and others, 2003), are relevant to understanding the geology and hydrology at SNL-2.

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. The basin filled with sediments, and it no longer significantly affected sedimentation. 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, continental environments prevailed, and significant redbeds were deposited. Although surrounding areas accumulated variable thicknesses of later Mesozoic and Cenozoic age sediments, the WIPP area appears to have mainly been subject to erosion during an extended period. Some basin tilting from 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-2

SNL-2 encountered a normal stratigraphic sequence along Livingston Ridge, northwest of the WIPP site area, from ground level to total depth (Table 2-1; Fig. 2-1). Units encountered ranged from unconsolidated surficial sands to the upper part of the Permian Salado Formation. No unusual structural, sedimentological, or diagenetic features were found during investigation using cuttings, cores, and geophysical logs, although details of the sedimentology of the Rustler will extend understanding of that unit. Units above the Rustler did not yield noticeable water during drilling.

The geologic units encountered in SNL-2 are described from total depth to the surface, in the order in which they were deposited rather than in the order in which they were encountered in the drillhole. Cores and cuttings were described in the field using mainly drilling depths for depth control. Geologic logs detailing field observations of cuttings and cores are included in Appendix C. The difference between geophysical logs and drilling depths is generally slight. The largest differences 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 Salado Formation

Only the uppermost Salado (~ 26 ft) was cored in SNL-2. The core provides a record of the transition from the Salado to the Rustler Formation and any dissolution that may have affected the upper Salado or basal Rustler.

Table 2-1
Geology at Drillhole SNL-2

System/ Period/Epoch		**Formation or unit**	**Member** *Informal units*	**Depth below surface (ft)**[1]
Cenozoic	Holocene- Pleistocene	surface dune sand and Berino soil[2]		0 - 3 ft
	Pleistocene	Mescalero caliche		3 - 7 ft
	Miocene-Pleistocene	Gatuña		7 ft - 104 ft
Mesozoic	**Triassic**	Santa Rosa[3]		eroded
		Dewey Lake[4]		104 ft - 277 ft
Paleozoic	**Permian**	Rustler	Forty-niner *A-5* *M-4/H-4* *A-4*	277 ft - 341 ft *277 ft - 312 ft* *312 ft - 324 ft* *324 ft - 341 ft*
			Magenta Dolomite	341 ft - 365 ft
			Tamarisk *A-3* *M-3/H-3* *A-2*	365 ft - 456 ft *365 ft - 428 ft* *428 ft - 440 ft* *440 ft - 456 ft*
			Culebra Dolomite	456 ft - 481 ft
			Los Medaños[5] *M-2/H-2* *A-1* *M-1/H-1*	481 ft - 588.3 ft *481 ft - 488.5 ft* *488.5 ft - 500 ft* *500 ft - 588.3 f* t
		Salado		588.3 - total depth (614 ft)

[1] Depths to 517 ft bgl are based on measurements by geophysical logging; drilling and coring provided data to total depth (TD) of 614 ft bgl. 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] Drillpad construction disturbed surficial materials. Units and depths are based on cuttings and exposures in wall of mud pit adjacent to drillhole.

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

[4] 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.

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

The program plan (Sandia National Laboratories, 2003) outlined a potential drilling target of a marker bed (possibly MB103) in the upper Salado. Powers (2002a) estimated before drilling that this location had not been affected by dissolution of upper Salado halite, based on the thickness of the interval between the Culebra Dolomite Member of the Rustler Formation and the Vaca Triste Sandstone Member of the Salado Formation in surrounding industry drillholes. The core provides direct stratigraphic and textural evidence to investigate any dissolution at the top of the Salado. Drilling beyond the uppermost Salado to an identifiable marker bed (possibly MB103) was expected to help in relating thickness changes of the larger stratigraphic interval to dissolution, if any, of upper Salado halite.

After the drillhole had been cored through the Rustler-Salado contact to 614 ft, the cored interval from 420 ft bgl was to be reamed to 7.875 inches diameter to 614 ft and then drilled on through MB103. The drillhole became unstable in the lower Rustler, below the Culebra Dolomite, and the decision was made to complete the well to the Culebra, as planned, rather than risk more serious complications by drilling deeper (see Appendix B). The core across the Rustler-Salado contact (Fig. 2-2) and the thickness data from surrounding wells were judged sufficent to evaluate upper Salado dissolution, and the additional data to be obtained by drilling deeper did not warrant the risks.

The upper Salado is dominated by coarse halite ranging in color from white to orangish or reddish-brown from included accessory minerals. Several depositional cycles (both Type 1 and Type 2, Lowenstein, 1988) are represented (Fig. 2-2), with sequences similar to those described by Holt and Powers (1990a,b). The basal halite beds of the depositional cycle are commonly coarse halite with few disseminated impurities, some thin bedding (2–8 inches), and some discontinuous thin sulfate laminae along bedding (stratified mud-poor halite; Fig. 2-2). Above this basal part of the cycle, the halite crystals tend to become smaller vertically, and clay (and sometimes polyhalite) content increases upward (muddy halite, possibly podular; Fig. 2-2). At the top of the cycle, some halitic mudstone or claystone may have accumulated (dilated mud-rich halite; Fig. 2-2), and the tops of the cycles at 605 ft, 594.8 ft, and 589.3 ft bgl display halite crystals that grew displacively in the clastics. Reddish-orange polyhalite, about 0.2 ft thick, begins the cycle from 605 ft bgl upward, and this is the best-defined Type 1 cycle in the cored interval. The thin (1 ft) anhydrite from 589.3–588.3 ft bgl is taken as the uppermost Salado, following Holt and Powers (1990a,b) and Powers and Holt (1999). This anhydrite marks the beginning of the fresher water in the basin that was followed by basal clastics of the Rustler Formation.

The lowermost cored interval, from 607.4–614 ft bgl, includes some white to clear sylvite (KCl). This zone is also marked by some large vugs apparently created by dissolving sylvite during drilling (Fig. 2-3). At least one vug appeared to include some remaining sylvite. No analyses have been performed on this interval.

2.2.2 Permian Rustler Formation

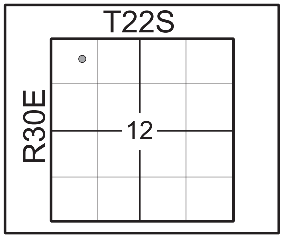
The Rustler was completely drilled. The contact with the underlying Salado Formation is at 588.3 ft, as marked on the core. The contact between the Rustler and the overlying Dewey Lake Formation is at 276 ft bgl, and the total Rustler thickness at SNL-2 is 308.3 ft.

2.2.2.1 Los Medaños Member

The Los Medaños Member of the Rustler Formation was named by Powers and Holt (1999) based on the rocks described in shafts at the WIPP site. For the area around WIPP, studies of the Rustler have commonly referred to this interval from the base of the Culebra Dolomite Member to the top of the Salado Formation as the unnamed lower member of the Rustler. Holt and Powers (1988) and Powers and Holt (1999) also informally subdivided the Los Medaños into five units: a bioturbated clastic interval at the base, a sandy transition zone, a lower mudstone-halite 1 (M-1/H-1), anhydrite-1 (A-1), and an upper mudstone-halite 2 (M-2/H-2). Halite

Figure 2-1
Well Record SNL-2 (C-2948)

Company: Washington TRU Solutions LLC
Well: SNL-2 (C-2948)
Section: 12□ Twp: T22S□ Rge: R30E
Location: 574 ft from north line (fnl)
859 ft from east line (fel)



Reference point
Log measured from: ground level (gl)
Drilling measured from: gl
Permanent Datum: gl

Elevation
KB:
DF:
GL: 3321 ft amsl
(benchmark: 3320.87)

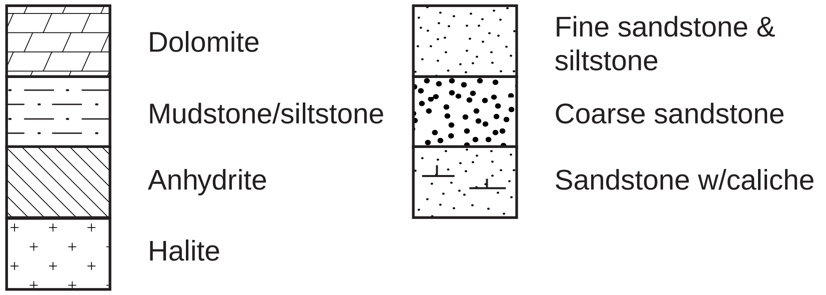
Drilling contractor: West Texas Well Water Service
Coring contractor: Diamond Oil Well Drilling Co.
Geophysical logs: Raymond Federwisch
Geophysical Logging Services (AZ)
Geologist: Dennis W. Powers
Spud date: April 28, 2003
Completion date: May 16, 2003
Total depth (TD): 614 ft bgl (driller log)

Casing Record
Conductor: 30 ft
13.375 inch steel
Casing: 5 inch o.d.
fiberglass to TD
Screened interval:
480.0-452.09 ft

Geophysical Logs Date: May 14, 2003	
Micro/Laterolog/Induction/SP:	0-517 ft
Gamma/Fluid:□	0-517 ft
Caliper:□	0-517 ft
Density/Neutron:	0-517 ft
Optical Televiewer:	0-500 ft

Type fluid in hole: Brine
Res mud: 0.38 ohm-m.
Res mud filtrate:
9.3 ohm-m.
Max. Rec. Temp.:
24.44^{o}C

General Lithologic Symbols Used



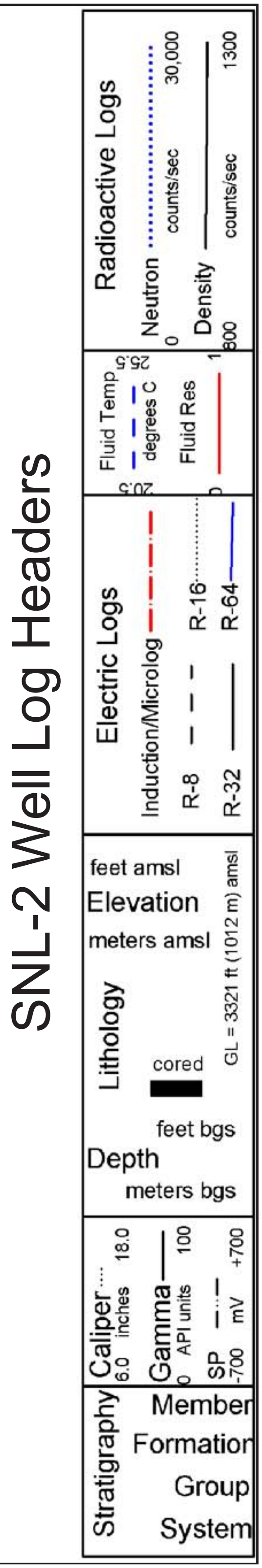


Figure 2-1 Log Title & Header page.ai

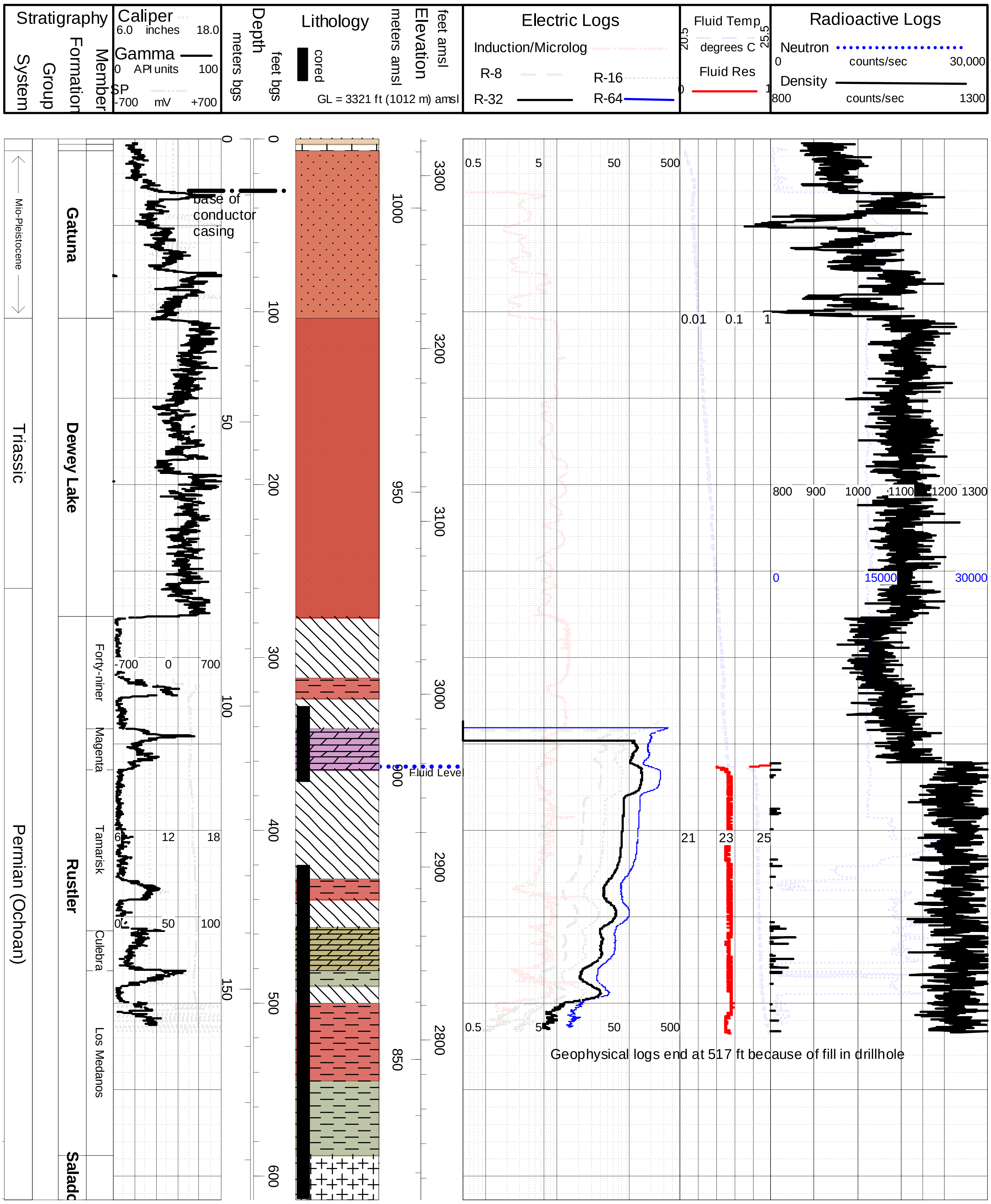
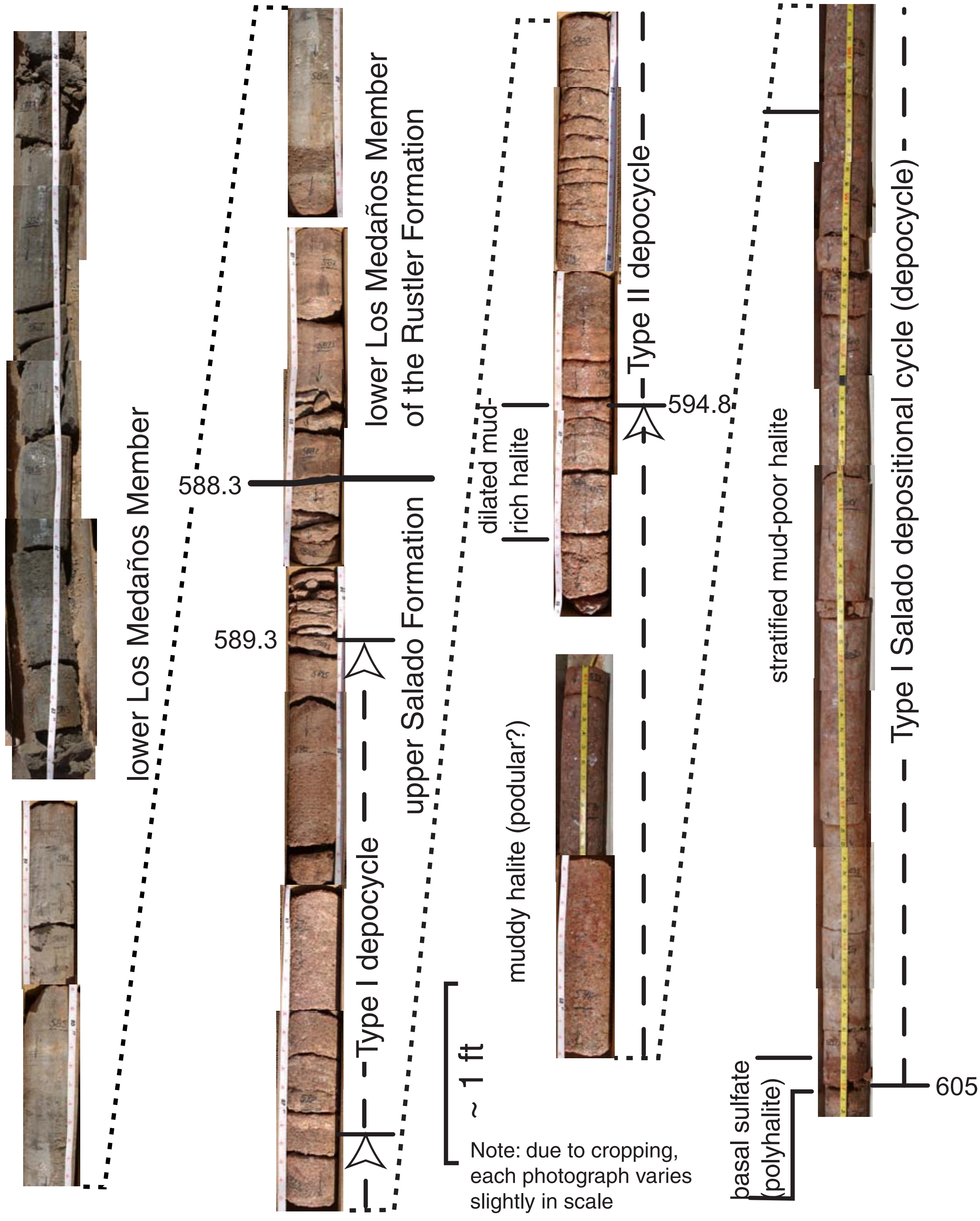

Stratigraphy
System
Group
Formation
Member
Caliper
6.0 inches 18.0
Gamma
0 API units 100
SP
-700 mV +700
Depth
meters bgs
feet bgs
Lithology
cored
Elevation
meters amsl
feet amsl
GL = 3321 ft (1012 m) amsl
Electric Logs
Induction/Microlog
R-8
R-16
R-32
R-64
Fluid Temp
degrees C
20.5
25.5
Fluid Res
0
1
Radioactive Logs
Neutron
0 counts/sec 30,000
Density
800 counts/sec 1300
Mio-Pleistocene
Triassic
Permian (Ochoan)
Gatuna
Dewey Lake
Rustler
Salado
Forty-niner
Magenta
Tamarisk
Culebra
Los Medanos
base of conductor casing
-700 0 700
6 12 18
0 50 100
0
50
100
150
0
100
200
300
400
500
600
1000
950
900
850
3300
3200
3100
3000
2900
2800
Fluid Level
0.5 5 50 500
0.01 0.1 1
21 23 25
800 900 1000 1100 1200 1300
0 15000 30000
Geophysical logs end at 517 ft because of fill in drillhole

Figure 2-2 Core Features for the Upper Salado and Basal Rustler Formations



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

Figure 2-3
Upper Salado KCl

margins for the Los Medaños below A-1 have been treated as a single composite unit (Powers, 2002a), called M-1/H-1 (Fig. 2-4), because halite below A-1 is not restricted to the thinner zone designated M-1/H-1 in these earlier publications.

The entire thickness (107.3 ft) of the Los Medaños was cored in SNL-2, although portions of the upper part were only partially recovered.

The informal unit *mudstone-halite 1* unit (M-1/H-1; Fig. 2-4) (Holt and Powers, 1988) is considered here to extend from the top of the Salado at 588.3 ft to 500 ft (based on geophysical logs), and it includes the bioturbated clastic interval and sandy transition without separation. The uppermost core from this interval was marked as 510 ft bgl.

At the base of M-1/H-1 at SNL-2, about 2 ft of reddish brown (2.5YR4/4; Munsell Soil Color Chart, 1971 edition; dry sample colors unless noted as wet) siltstone overlies the anhydrite considered the top of Salado (Fig. 2-2). The siltstone is thin bedded to laminar, with an erosional contact about 1 ft above the base. Small sulfate clasts are included in the siltstone. The erosional contact is stratigraphically equivalent to more substantial evidence of erosion and channeling observed elsewhere in WIPP shafts and cores (Holt and Powers, 1990a,b; Powers and Holt, 1999).

From about 586 to 545.3 ft bgl, M-1/H-1is dominated by gray (10YR5/1–5Y5/1) silty sandstone and sandy siltstone. Thin laminae to thin beds are common, as is low-angle cross-bedding. Some of the bedding appears modestly disturbed by bioturbation, especially in the lower third of this zone. Holt and Powers (1988) also informally described this portion of the Los Medaños as the bioturbated clastic interval.

Within part of this same interval, the cores revealed several sub-vertical fractures 3–4 ft in length, as well as a horizontal fracture filled with about 1 inch of halite at 554 ft bgl. A vertical fracture (Fig. 2-5) with an upper limit at about 567.7 ft shows a scalloped plane and no fill except near the base. A vertical fracture from 547–550 ft is filled with about 0.5 inch of fibrous orange halite (Fig. 2-6). A few narrow fractures, with little or no fill, at greater angles from vertical are revealed by the core in this interval.

The interval from about 545.3 ft to the top of core recovered at about 527.2 ft bgl is fine to very fine sandstone that tends to be dark reddish gray (5YR4/2) to dark brown (7.5YR4/4); some interbedded sandstone below 538.3 ft bgl is gray (10YR5/1). The sandstone is commonly laminar (0.04 inch and thicker) to thinly bedded. Bedding is mostly horizontal to subhorizontal, with some ripple bedding about 0.5 inch high. Small gypsum clasts (~ 0.04 inch) at about 533 ft bgl appear to grade or fine slightly upward.

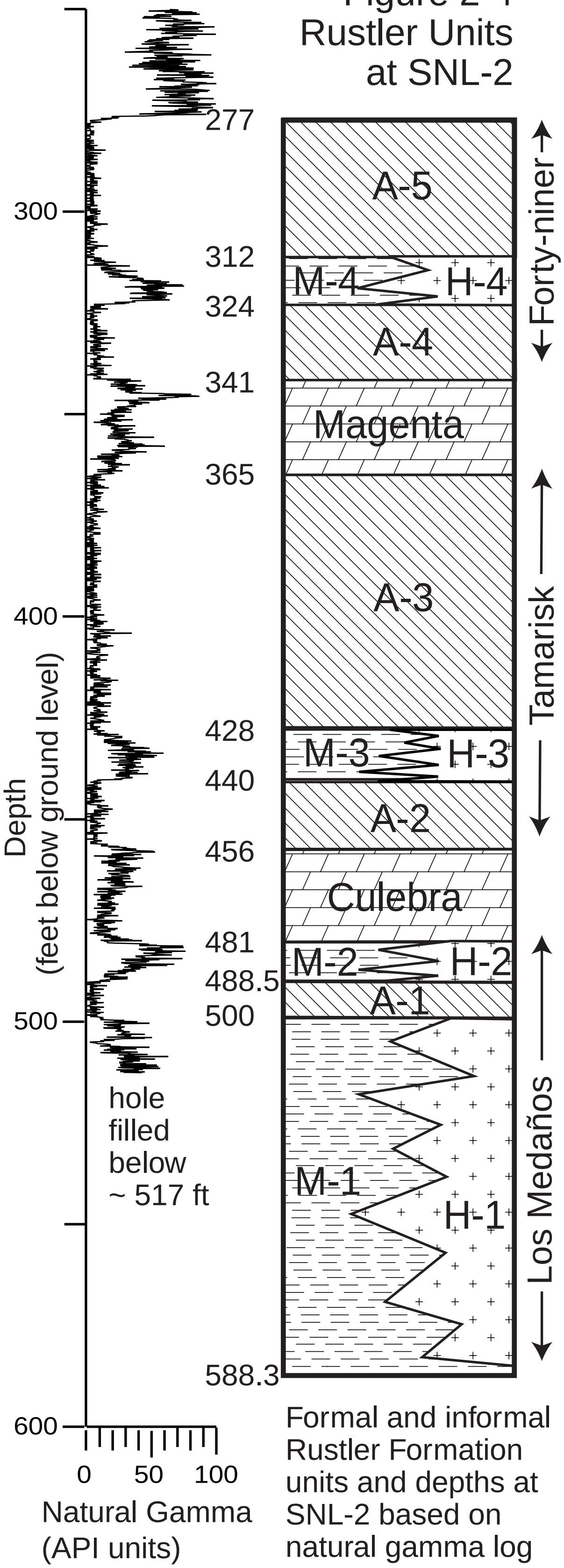
Above a zone of lost core, the uppermost 2 ft of M-1/H-1 consist of fine-grained silty sandstone that is reddish brown (2.5YR4/4) that includes some white, brown, and bluish-gray interlaminated sandstone and sulfate laminae (0.04–0.2 inch). The sandstone is crumbly, with moderately rounded and sorted grains.

M-1/H-1 is variably cemented. Coring from about 527 ft bgl recovered nearly continuous samples, and the section from 527.2 ft to about 577 ft is well-indurated. It is mainly cemented by halite, and this cement likely accounts for good sample recovery. The interval is also slightly calcareous. Halite cement in part of the interval is clearly poikilotopic, with halite crystals as large as 2 inches visible on the core surface. Sedimentary textures are not observably disrupted by crystal growth, and sand grains remain in grain to grain contact.

Most of the sample recovered from the upper 2 ft of M-1/H-1 is poorly preserved, with mostly crumbly sand that is slightly calcareous. A thin segment (~ 0.4 ft) appears to be cemented with sulfate.

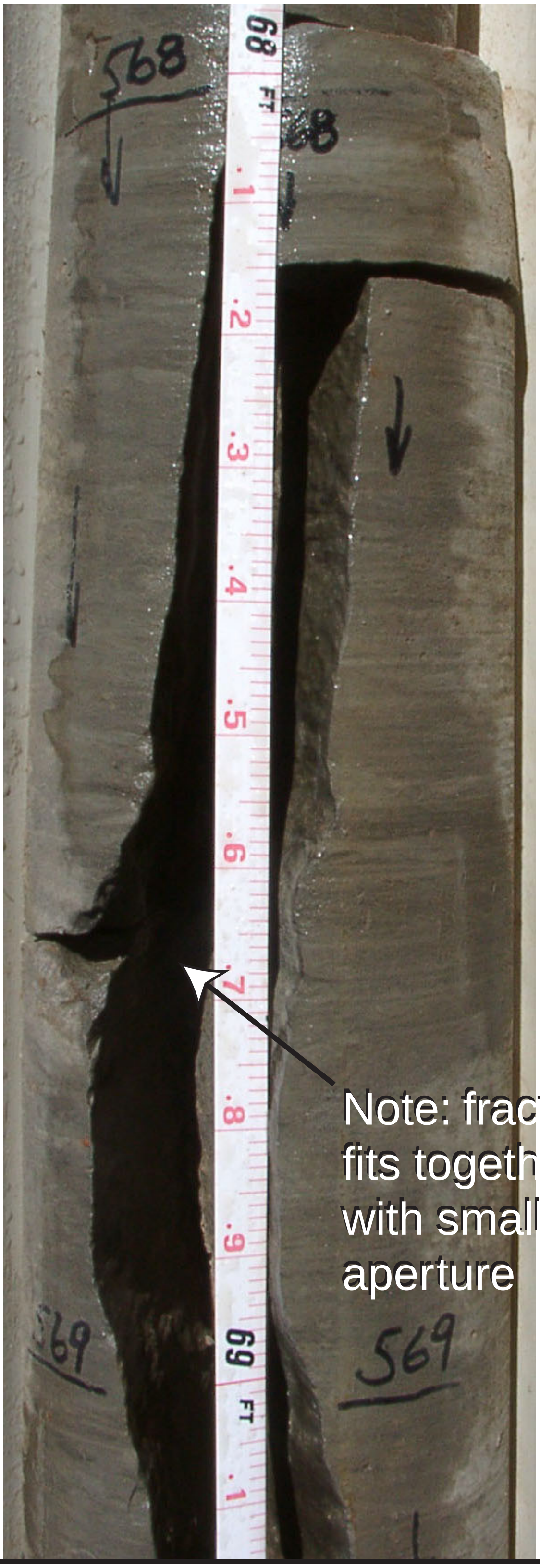
The informal unit *anhydrite 1* (A-1; Fig. 2-4) (Holt and Powers, 1988) was encountered from 488.5–500 ft bgl, based on the natural gamma and caliper logs from SNL-2 (Figs. 2-4, 3-1). Based on the drilling records and apparent loss of core from the unit above A-1, the core of A-1 was

Figure 2-4
Rustler Units
at SNL-2



Formal and informal Rustler Formation units and depths at SNL-2 based on natural gamma log

Figure 2-5
Unfilled Fracture



Note: fracture fits together with small aperture

Figure 2-6
NaCl-filled Fracture

attributed to the interval from 497–510 ft bgl, and it was marked accordingly. The core has not been re-marked. The sedimentology of A-1 is discussed according to core depth markings.

A-1 at SNL-2 is expressed as three subunits: a basal anhydrite, a claystone, and an upper anhydrite with a thin polyhalitic zone.

The basal white to gray anhydrite is 1.6 ft thick. Thin laminae (~ 0.04–0.2 inches) characterize this subunit, while the upper part is somewhat brecciated, with siltstone or claystone infill.

The claystone between the anhydrites of A-1 is about 1.1 ft thick, silty, reddish brown (2.5YR4/4), and slightly calcareous. Bedding is faint on the core surface. Small (~0.04–0.2 inch) angular clasts of gypsum in the lower 0.4 ft of the claystone appear slightly graded upward. The contact at the top appears relatively sharp and undisturbed.

The upper sulfatic subunit of A-1 is about 10.3 ft thick, gray, finely crystalline, with some laminar to wavy bedding (~ 0.04–0.4 inch). There are small features (~0.08–0.12 inch high), possibly swallowtail gypsum or pseudomorphs, at about 500 ft. A pinkish zone at about 505 ft may indicate an earlier polyhalite, as the natural gamma log does not show evidence of potassium that would be present in a polyhalite. A similar stratigraphic zone in A-1 is polyhalite in some drillholes farther to the southeast (Holt and Powers, 1988).

The upper part of A-1 includes some vertical to subvertical fractures, most of which are healed by gypsum. A few small vugs or pores along subhorizontal zones appear to be plucked or eroded gypsum that filled subhorizontal separations in the unit.

The upper contact of A-1 is gradational over about 0.4 ft. This zone consists of angular to subrounded gypsum clasts with reddish brown siltstone matrix that increases upward.

The informal unit *mudstone-halite 2* (M-2/H-2; Fig. 2-4) (Holt and Powers, 1988) was encountered from 481–488.5 ft bgl, based on the natural gamma and caliper logs from SNL-2 (Figs. 2-4, 3-1). The core from M-2/H-2 was marked according to the apparent depths of A-1 from drilling rates, and it was inferred at the time that several feet of M-1/H-1 had been lost. The thickness of the unit (7.5 ft) based on geophysical logs indicates that nearly all of the core (~7 ft) from M-2/H-2 was recovered. Core loss from below A-1 was greater than was inferred at the time of recovery. Core marks placed in the field (484.5 ft at top and 497 ft at base) have not been changed, and the unit is discussed according to core depth markings.

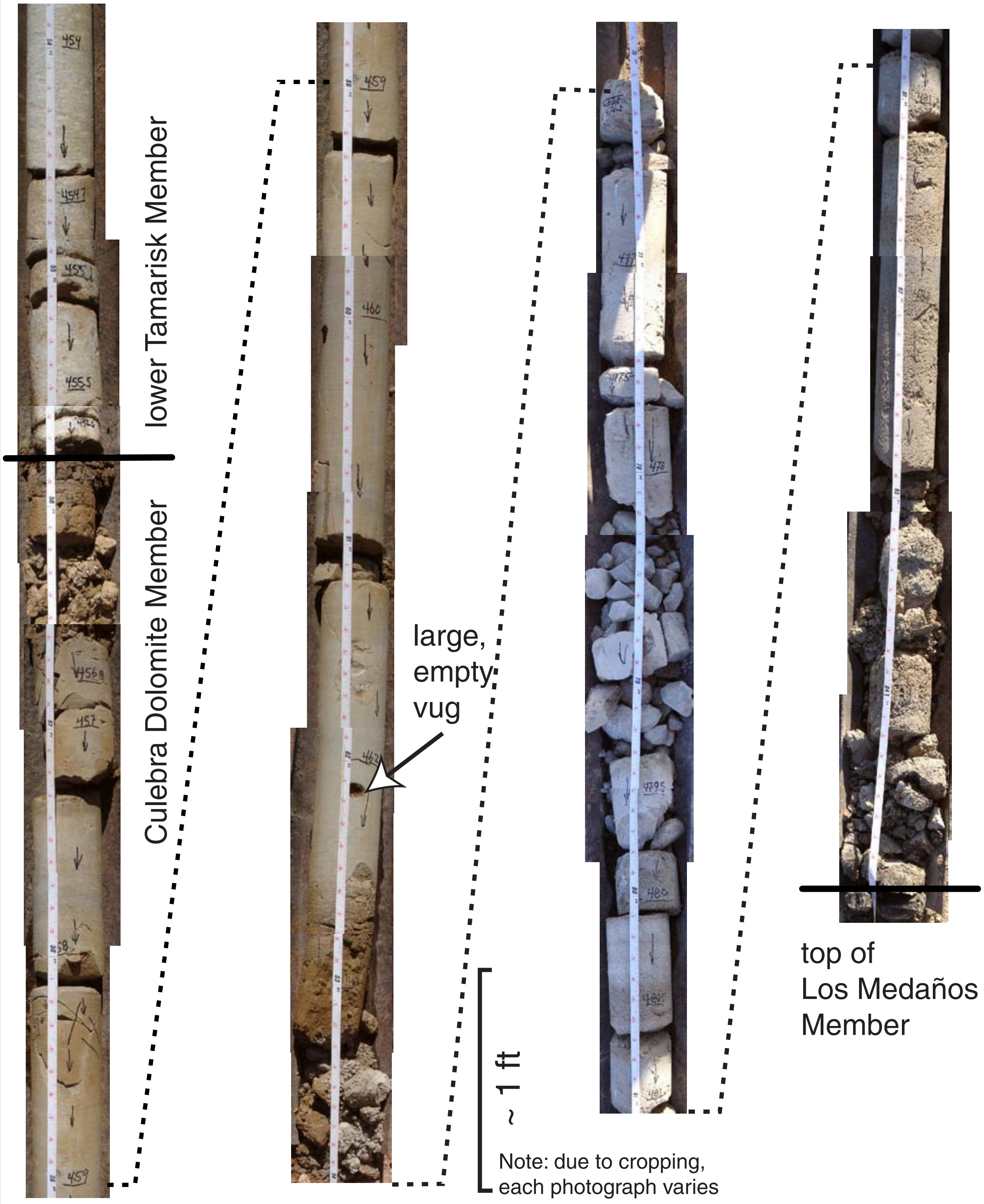
M-2/H-2 at SNL-2 is mainly calcareous, argillaceous siltstone with a thin, sticky, laminated black claystone (marked 485.1–484.5 ft bgl) at the top. Bedding is discernible but intermittent. M-2/H-2 is mainly gray (7.5YRN6) from the claystone down about 1.5 ft (to zone marked 491.6 ft bgl). The lower 6–6.5 ft, to the top of A-1 at 497 ft, is weak red (2.5YR4/2) mottled gray. There are scattered blebs or clasts of gypsum in M-2/H-2 above a basal 1-ft-thick zone of graded gypsum clasts. Fibrous gypsum, perpendicular to fracture planes, fills some horizontal separations as well as some fractures at 35-45^o from vertical. The upper contact with the overlying Culebra Dolomite Member appears sharp, but core recovered from this zone was fractured.

2.2.2.2 Culebra Dolomite Member

Based on the natural gamma log from SNL-2, the Culebra extends from 481.0 to 456.0 ft bgl, a thickness of 25 ft (Figure 2-1). Based on drilling depths available at the time, the recovered Culebra core was marked from 484.5 to 455.7 ft bgl (as used in information in Appendices C and F). Recovered Culebra core (Fig. 2-7) totals about 14.5 ft thick, indicating a core loss of about 10.5 ft from this unit. Based on the drilling activity and recovery of adjacent units, the core loss was attributed to the middle of the Culebra (see Appendix C, sheets 5 and 6).

Holt and Powers (1988) found a range of 20–30 ft thickness in Culebra cores described from the WIPP project and a regional thickness exceeding 40 ft, based on geophysical log data. Significant core loss in the middle of the Culebra is common because of the porosity of that zone.

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



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

The Culebra at SNL-2 is a light gray (2.5YR7/2) to dark grayish brown (10YR4/2, wet) silty dolomite with a thin yellowish brown (10YR5/4) zone from 462.8–463.4 ft bgl.

The basal dolomite marked at 484.5 overlies the black claystone of the Los Medaños as a continuous unit. From 484.5–479.3 ft, the Culebra is porous, but the pores are small (0.04–0.08 inch diameter), and the zone is silty. Short (~ 1–2 inches) fracture planes and some brecciation are visible in the lower 2 ft of the zone, and the textures appear similar to the packbreccias reported elsewhere from the zone (e.g., Holt and Powers, 1988). A few larger pores or vugs above 481 ft in this interval are filled with gypsum. This interval generally corresponds to the hydrogeological interval CU-4 defined by Holt (1997).

From 479.3–476.1 ft (the top of the lower recovered core), the Culebra displays larger vugs (to ~ 1 inch) with little to no gypsum fillings and few small vugs or pores. Some of the vugs appear partially filled with dolomite silt, but surficial vugs may have accumulated some fill during drilling. This interval also includes subvertical fractures, some filled with fibrous gypsum and some without filling. The separation of filled fractures can reach ~ 0.1 inch. The core from this interval is rubbly, and the surfaces on individual pieces suggest natural bedding plane separations, sub-vertical fractures, and some breakage during coring because of large pores. This interval likely represents the lower part of CU-3 defined by Holt (1997).

The lowest Culebra core recovered from core run 4, marked from 463.3–462.8 ft, is yellowish brown in color and is distinctly different from the overlying dolomite. It does not show obvious lithologic differences, but it retained moisure longer after coring and likely is more porous. This zone is fine grained, faintly bedded, and displays horontal bands of characteristic pores that range from open to filled with gypsum. This is similar to other Culebra cores (e.g., Holt and Powers, 1988; Powers and Holt, 1990; Holt, 1997). A subvertical fracture crosses the interval. This unit may mark the upper boundary of the hydrogeologic unit CU-2 defined by Holt (1997); CU-2 is apparently otherwise not represented in the retained cores from SNL-2.

From 462.8–456.6 ft, the Culebra is dark grayish brown (10YR4/2, wet), and it is well-indurated. A few larger (~ 1 inch diameter) open vugs are scattered through the interval, and there are some with gypsum fillings; there are very few small vugs. Subvertical to high-angle fractures are present through this interval, spaced out on the order of 1 ft (vertical). Some fractures have no filling, and very small apertures. Others have gypsum fillings.

A thin (0.9 ft) organic-rich dolomite from 456.6–455.7 ft marks the top of the Culebra and the sharp transition to the Tamarisk Member. This thin interval is porous and less well-indurated than the underyling dolomite. It also appears to have less organic material than in some shafts or cores elsewhere (e.g., Holt and Powers, 1988).

The geophysical logs of the Culebra provide some additional details of the unit. The natural gamma decreases to a relatively low value of about 10–15 API units (Fig. 2-4) near the base of the unit and then increases more or less uniformly to the top. This most likely represents a modest but uniform increase upward in clay minerals and possibly organic content. The fluid resistivity log shows a slight, but distinctive, lower resistivity zone from 460–476 ft. Culebra water is much lower salinity (higher resistivity) than is the brine used to drill the borehole, and local mixing should have increased fluid resistivity. It is possible the fluid resistivity log is affected by the combined resistivity of rock and included fluid in adjacent strata in the drillhole, as the fluid resistivity does locally seem to reflect deeper formation resistivity trends. The formation resistivity through the Culebra shows the following trends: reduced resistivity compared to the overlying anhydrite (A-2) with the lowest resistivity in the lowest 4–6 ft (~475–481 ft). The neutron log indicates local reduction through the intervals from 474–463 ft and 460–456 ft. The most significant neutron reduction in the Culebra is the interval from 475–481 ft, corresponding to the lowest resistivity zone. This basal zone is likely the most porous (and transmissive) interval of the Culebra. The upper zone of somewhat reduced neutron flux may indicate increasing organic content through the uppermost Culebra and basal Tamarisk along with gypsification of the basal Tamarisk.

2.2.2.3 Tamarisk Member

The natural gamma log of SNL-2 shows that the Tamarisk Member occurs from 456–365 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-2/H-2, and A-3, respectively, and showed that the lateral gradation from mudstone M-2 to halite H-2 reflects lateral changes in deposition. SNL-2 is located in the mudflat or M-2 facies of these beds. The basal 37.5 ft and upper 9 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. 2-4) (Holt and Powers, 1988) at the base of the Tamarisk is 16 ft thick (456–440 ft bgl) on the geophysical logs. Core retained from the interval was marked from 455.7–439.5 ft, an interval thickness of 16.2 ft. A-2 is predominantly gray gypsum, but some anhydrite is also present.

Above the contact with the Culebra (Fig. 2-7), A-2 has subhorizontal bedding, and the core surface suggests some small nodules are present. An argillaceous zone in the core from about 446–447 ft appears to be matched by a narrow zone of increased natural gamma in the geophysical log. Subvertical fractures with gypsum filling increase in abundance toward the top of the Culebra. From 441–445 ft, the gypsum is bedded, and there is a minor amount of reddish brown material, probably clay, around crystal boundaries and along some bedding. It is unclear from the core surface whether this material infiltrated from the overlying claystone or is evidence of the change in depositional environment. The upper 1.5 ft of A-2 reveals little structure on the core surface. The upper boundary of A-2 with the overlying claystone is sharp and slightly inclined from horizontal.

The informal Tamarisk unit *mudstone-halite 3* (M-3/H-3; Fig. 2-4) (Holt and Powers, 1988) is 12 ft thick (440–428 ft bgl) at SNL-2, based on the geophysical logs. The cored interval marked from 439.5–428.5 ft corresponds to the logged interval, and the thicknesses are consistent within the limits of interpreting the logs.

From 439.5 to ~432.3 ft, M-2/H-2 is reddish brown (2.5YR4/4) sandy claystone that is bedded on ~1 inch scale. A few clasts of gray siltstone/claystone are included. Subhorizontal gypsum veinlets with vertical fibrous gypsum are commonly spaced ~1–3 inches vertically. The surfaces of the claystone adjacent to these veinlets are commonly slickensided. Thicker fibrous gypsum occurs in more fractures more widely spaced and at about 45 degrees from vertical. The gypsum in subvertical fractures appears to have formed later than the gypsum filling subhorizontal separations.

From ~432.3 ft upward, M-2/H-2 is mixed gray gypsum and mixed gray and reddish brown siltstone and claystone. Gray colors increase upward. At about 430.5 ft, interbedded gray and reddish brown siltstone is preserved. Intraclasts of gray siltstone are included in some of the upper reddish brown siltstone. Somewhat angular clasts of gray gypsum (maximum dimension about 2 inches) are included. Some gypsum veinlets at high angles are preserved in this upper interval, and there are also white gypsum crystals that may have grown displacively. The upper contact appears sharp and possibly truncated by sandy gypsum.

The neutron log for this interval shows a sharp decrease in neutron flux over the upper 6 ft, from 434–428 ft. This corresponds to the gray zone, which also includes more gypsum.

The informal unit *anhydrite 3* (A-3; Fig. 2-4) (Holt and Powers, 1988) occurs from 428–365 ft bgl on geophysical logs, a thickness of 63 ft. Core markings for the base and top, respectively, for this unit are 428.5 ft and 363.3 ft, for a thickness of approximately 65 ft. The upper and lower contacts were cored, and the main part of the unit was drilled.

About 8.5 ft of the basal A-3 was cored, and this part of the unit is mainly gray gypsum, with some anhydrite increasing upward. The gypsum is well-indurated, with fine to very coarse crystals. Thin beds are subhorizontal to inclined at low angles. From 428.5–425.5 ft, the gypsum has been brecciated, and there is some gray siltstone and claystone between clasts. There are gypsum-filled fractures at ~ 60 degrees from vertical and spaced about 4–8 inches vertically.

Cuttings from the drilled interval of A-3 were poor, and they were considerably mixed with material from higher stratigraphic units, in part because the higher cored section had to be reamed before drilling could begin. The geophysical logs do not indicate any unusual lithology for this interval.

About 9 ft of core were obtained of the upper part of A-3, from 363.3–372.3 ft. The core consists of light gray anhydrite and gypsum that is fine to coarsely crystalline. Thin laminar zones were encountered at 372–371 ft, 368.9–368.5 ft, and 365–364 ft. Some organics may be present at 372–371 ft.

The upper contact with the Magenta is transitional over an interval of about 0.5 ft; it has been placed at the base of the transition zone.

The Tamarisk stratigraphy and thickness are consistent with other drillholes and shafts in the area (Holt and Powers, 1988). A-2 and M-2 are each a few feet thinner than in many other holes, and A-3 is a few feet thicker; the differences are consistent with depositional variations and do not suggest unusual conditions.

2.2.2.4 Magenta Dolomite Member

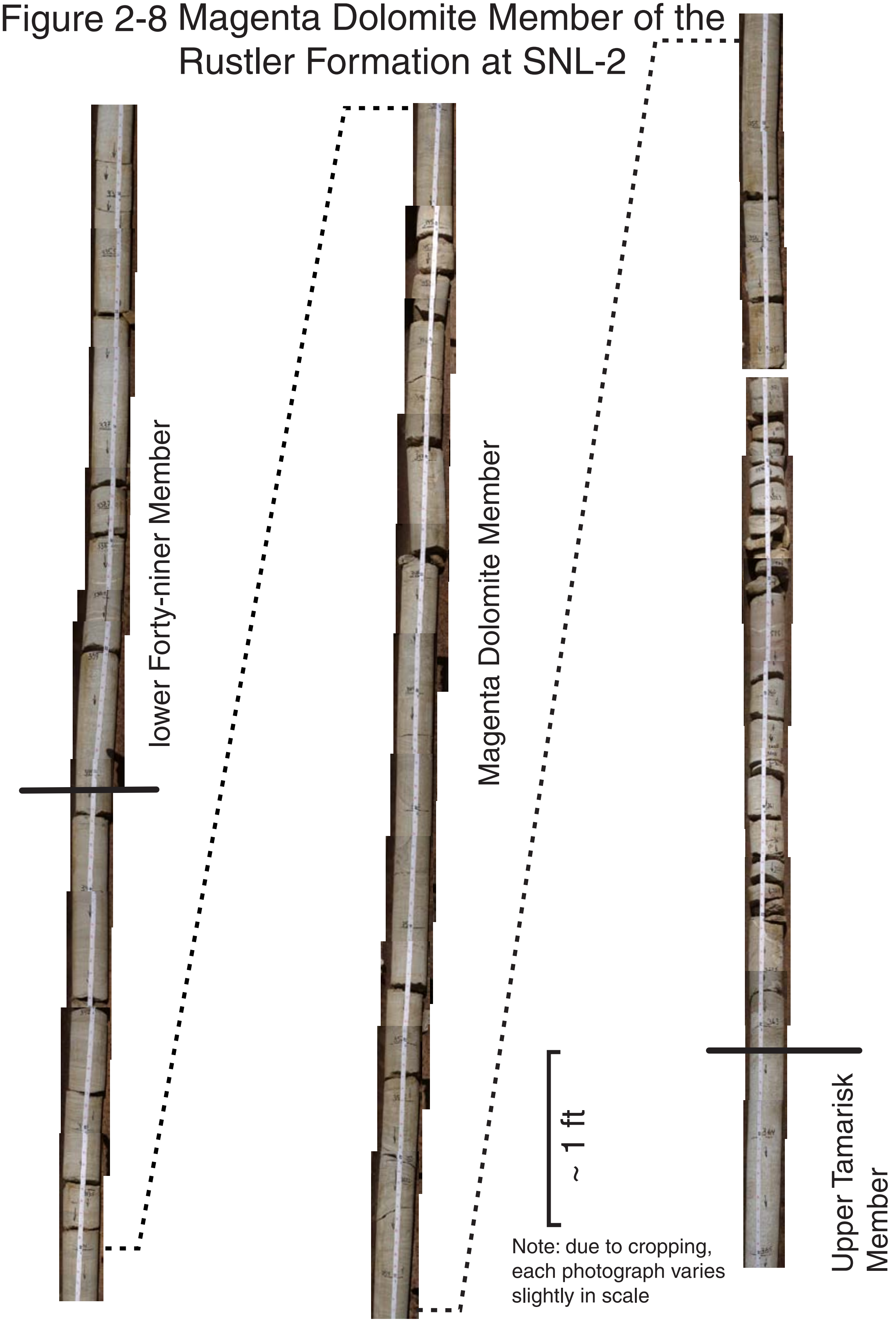
The Magenta Dolomite Member at SNL-2 is 24 ft thick (365–341 ft bgl) based on geophysical logs. Core from the Magenta is marked from 363.3–340.2 ft, a thickness of about 23 ft (Fig. 2-7). The entire unit was cored; recovery was good, although some zones were fragmented.

The Magenta consists of dolomite and gypsum, and it is commonly light brown (2.5Y8/2–white or 2.5Y7/2–light gray) in core. In SNL-2, a thin zone of pale red (10R6/2) occurs from 359.8–359.2 ft. 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-2, like outcrops and shaft exposures of the Magenta, is strong wavy to laminar bedding along with zones of algal stromatolites. Wave amplitudes commonly decrease upward from the base toward the middle of the unit and then increase slightly upward toward the upper contact. In the lower Magenta, amplitudes range from about 0.1–0.2 ft (Figure 3-7). Bedding amplitude is more commonly about 0.25–0.5 inch in the middle and upper part of the Magenta. Some small ripple bedding is evident in the Magenta. Near the base of the Magenta at SNL-2, the wavy bedding includes very thin, dark laminae draping the high points. These are interpreted as stromatolites, consistent with well-exposed algal features in the air intake shaft (Holt and Powers, 1990a; Powers and Holt, 1990). Other possible algal laminae are present at 358 ft and 345–346 ft bgl.

About half the length of the Magenta, from about 357–344 ft bgl, has been fractured, with orientations ranging from about 45 degrees from vertical to subvertical upward. Some blocks have been rotated and further brecciated in the lower part of the fractured zone. A few blocks show some plastic deformation. The vertical displacements are generally small (< 0.1 ft) and decrease upward. Some of the fractures are filled with gypsum. A short vertical fracture below 361 ft is also filled with fibrous gypsum. The fractures do not show macroscopic porosity, and the zone does not show obvious evidence of increased porosity. This zone of fracturing appears to correlate generally to the lower natural gamma in the middle of the Magenta from 347–345 ft bgl.

The core of the Magenta does not show surface evidence of open porosity or porosity zones. The induction log through the Magenta displays some vertical variability, with lower resistivity at 357 ft and 345 ft, at the same positions as two high points in the natural gamma log. Between these points, the

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



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

higher resistivity corresponds approximately to the fractured zone.

The upper contact of the Magenta with the overlying Forty-niner Member, as placed on the core, is sharp but continuous. As described later, dolomite was intermittently deposited in the lower Forty-niner.

The Magenta is typical in thickness, composition, and sedimentary features. The fractured zone is more extensive than in most cores and shafts from the center of the WIPP site. The zone of lower natural gamma, corresponding approximately to the fractured zone, is not typical of the middle of the Magenta; that zone commonly is marked by the highest natural gamma.

2.2.2.5 Forty-niner Member

The Forty-niner Member at SNL-2 is 64 ft thick (341–277 ft bgl), based on geophysical logs. A change in drilling rates was noted at a depth of about 280 ft, consistent with the logging depths. 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 328 ft bgl. All Forty-niner coring took place in the lower sulfate beds of the member. Like the Tamarisk, the Forty-niner consists of upper and lower anhydrites with a middle unit that ranges from siltstone and claystone at SNL-2 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, and 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) (Holt and Powers, 1988), is gray to white gypsum and anhydrite ranging from very coarse gypsum to finer anhydrite. A-4 is 17 ft thick, based on geophysical logs as well as drilling. The recovered core of A-4 displays some wavy bedding, and the lower 3 ft of core include thin dolomite beds similar to the Magenta. 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 340.2 ft (as marked on the core). The environmental transition was not as sharp, given the additional dolomite above that contact. A brown siltstone was recovered from 332.1–331.9 ft bgl.

A-4 reveals numerous thin (generally < 0.2 inch) gypsum veinlets, with vertical fibers, along bedding separations.

Mudstone-halite 4 (M-4/H-4; Fig. 2-4) (Holt and Powers, 1988) is about 12 ft thick (312–324 ft bgl), based on the natural gamma log. Cuttings from M-4 provided siltstone and silty claystone that was red (2.5YR4/6, wet) and non-calcareous. The basal part of M-4 is typically gray, but cuttings of this interval were not retained.

The upper sulfate unit, *anhydrite-5* (A-5), is white (10YR8/1), and it is about 35 ft thick (312–277 ft bgl) at SNL-2. Cuttings from the interval in SNL-2 were mainly fine–grained gypsum. A zone about 8 ft thick of increased neutron flux near the middle of A-5 suggests a higher proportion of anhydrite.

2.2.3 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-2, the Dewey Lake is 173 ft thick (277–104 ft bgl), and it is composed mainly of red (10R4/6) interbedded sandy claystone, siltstone, sandy siltstone, and fine–grained sandstone. Small (< 0.04 inch) light olive brown (2.5YR5/4) reduction spots are a common characteristic of the Dewey Lake at SNL-2 and elsewhere. Most of the Dewey Lake is described on the basis of cuttings, drilling rates, and geophysical log characteristics.

Geophysical logs from SNL-2 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, 2003) and applied to other drillholes such as C-2737 (Powers, 2002b).

Only the lower two of three general depositional regimes for the Dewey Lake Formation can be distinguished on natural gamma logs of SNL-2, and the second is only partially preserved.

The interval from 277–195 ft bgl in SNL-2 displays the natural gamma and resistivity (induction) features of the lower Dewey Lake informally called the *basal bedded zone* (Powers, 2003). The natural gamma fluctuates around a similar value (~ 70 cps in this case) over this vertical interval, and there are no apparent trends over the entire interval. The resistivity tends to fluctuate as well, on a vertical scale of ~4–15 ft. The fluctuations appear to correlate across boreholes, suggesting broad scale bedding, and the interval corresponds to a bedded section clearly exposed in the air intake shaft (Holt and Powers, 1988).

The interval from 195–104 ft bgl (91 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 (Powers, 2003). A sandstone unit from ~194–186 ft bgl is at the base of this interval.

The interval of fining upward cycles is truncated at SNL-2 by erosion by the overlying unit. Near the center of the site, this interval is more than 300 ft thick; at C-2737 it was 260 ft thick (Powers, 2002b). At SNL-2, sandstones of the upper fining upward cycles are removed by erosion. Smaller fining upward cycles are not defined, and the trend over much of the interval appears to be mainly a broad fining upward.

The upper coarsening interval of the Dewey Lake at SNL-2 has been removed by erosion. The broad sedimentological units definable by natural gamma logs for the lower Dewey Lake are present and are generally representative below the erosional surface.

Cuttings from the upper Dewey Lake were slightly calcareous to a depth ~175–180 ft bgl. From about 170 ft bgl, cuttings included some clear gypsum crystals. Resistivity measured by induction shows a change in character at ~184 ft bgl, increasing somewhat below that point. The neutron flux decreased slightly below that point and may also reflect the significant presence of gypsum below ~186 ft. The optical televiewer log of the upper part of SNL-2 shows narrow white planar features, starting at 184 ft bgl, that are interpreted as gypsum fracture fillings.

The boundary between natural carbonate (above) and sulfate (below) cements in the Dewey Lake is in the range from 170–184 ft bgl, with a most likely location at 184 ft bgl. This cement change is observable in other cores from the area (Powers, 2002b, 2003), and it was reported in the air intake shaft (Holt and Powers, 1988).

The carbonate–sulfate cement boundary in the range of 170–184 ft bgl is stratigraphically lower in SNL-2 than it is at the middle of the site at drillhole C-2737 (Powers, 2002b) or at the air intake shaft (Holt and Powers, 1990a). This change is consistent with the boundary dropping stratigraphically as the Dewey Lake is more exposed to erosion and weathering (Powers, 2003).

On the basis of the resistivity (induction) log (Fig. 2-1), the Dewey Lake is likely to be more transmissive above about 184 ft bgl, at or near the carbonate–sulfate boundary. The induction log also reveals a rather uniform and relatively high resistivity from 150–104 ft, the uppermost 46 ft of the Dewey Lake at SNL-2. This can indicate a zone of uniform lower transmissivity, but the geological reasons are not known from the limited cuttings and log data.

2.2.4 Miocene-Pleistocene Gatuña Formation

Based on the cuttings from drilling and geophysical logs, the Gatuña occurs from 104–7 ft bgl. The Gatuña at SNL-2 is primarily light reddish brown (2.5YR6/4) to reddish brown (2.5YR5/4–4/4) sandstone with interbedded argillaceous siltstone. A thin zone of pinkish gray (5YR6/2) argillaceous sandstone with quartzite pebble pieces was encountered from 61–62 ft bgl.

Gatuña sandstones are slightly calcareous to very calcareous, with calcite increasing in the upper portion where pedogenic calcrete has infiltrated the unit. Sand grains are subangular to rounded and very fine to very coarse. Opaque grains can reach an estimated 3–5% of the grains. MnO_2 (manganese oxide) stains some of the cuttings, probably from pedogenic processes. The formation is porous and mottled due to pedogenic processes.

The Gatuña generally increases in thickness to the west, and the depositional edge of the formation at the WIPP site is in the same general area where the Santa Rosa pinches out because of erosion that preceded Gatuña deposition (Powers and Holt, 1993). The Gatuña is relatively thick at SNL-2, as it is along the Livingston Ridge escarpment immediately west of the drillhole location (Fig. 2-9). More than 80 ft of Gatuña sediments are exposed there, and no Dewey Lake outcrops have been found in the immediate vicinity. Bachman (1985) also found thicker Gatuña in this area and suggested it was filling an erosional valley. The SNL-2 data are consistent with this interpretation.

The Gatuña ranges in age from at least 13.5 to ~ 0.5 million years old (Powers and Holt, 1993). SNL-2 is located less than 2 miles south of outcrop of Lava Creek B ash found at the top of the Gatuña by Bachman (Bachman, 1980; Izett and Wilcox, 1982). From general relationships along Livingston Ridge, the Gatuña at SNL-2 includes younger portions of the unit range, but it may also represent a significant portion of the age.

2.2.5 Pleistocene Mescalero caliche

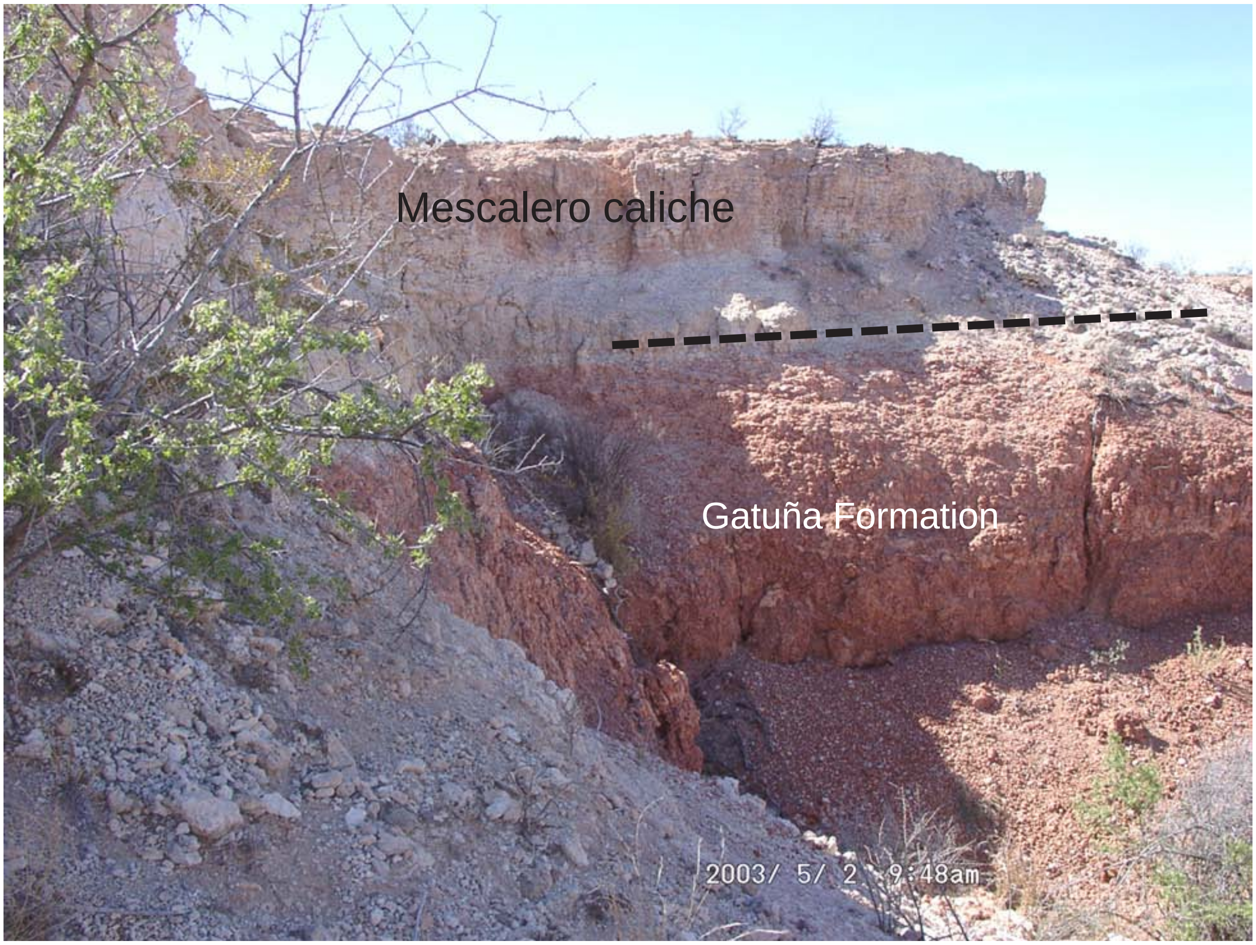
The Mescalero is an informal soil stratigraphic unit defined by Bachman (1973). It is widespread in southeastern New Mexico, and it is a continuous stratigraphic unit at the WIPP site. Uranium-disequilibrium ages indicate the Mescalero formed as a pedogenic unit between ~570,000 (± 100,000) and about 420,000 (± 60,000) years ago (Rosholt and McKinney, 1980). The age is further bounded by the Lava Creek B ash, about 600,000 years old, which underlies the Mescalero less than 2 miles north of SNL-2 along Livingston Ridge (Izett and Wilcox, 1982).

At SNL-2, the Mescalero is ~4 ft (7–3 ft bgl) thick. From cuttings and from exposures in the adjacent mud pit and along nearby Livingston Ridge, the Mescalero shows evidence of pedogenic processes such as nodule, ped, and laminae development. Not only is the unit strongly calcareous, the upper portion of the unit is locally plugged and subhorizontal laminae are partially developed at the upper surface. 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 is generally at stage V in the vicinity of WIPP, as it is at SNL-2.

2.2.6 Pleistocene Berino Soil and Surficial Sands

The Berino is a yellowish-red (2.5YR5/6) sandstone that is friable and argillaceous. Sand grains are very fine to medium. The Berino soil is not a geologic unit; it is a pedogenic unit defined by the soil scientists in the area (Chugg and others, 1971). From SNL-2 to the Livingston Ridge escarpment, the Berino has generally been removed by erosion and may only locally be preserved. Grayish brown dune sand, stabilized by vegetation, and thin surficial colluvium and eolian silt overlie the Mescalero where it has not been completely exposed. These materials, with imported Mescalero caliche, were used to construct the drilling pad, forming about a 3-ft fill over the surface of the Mescalero.

Figure 2-9. Mescalero Caliche Overlying Upper Gatuña Formation at Livingston Ridge Northwest of SNL-2.



3.0 PRELIMINARY HYDROLOGICAL DATA FOR SNL-2

SNL-2 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 a pumping test and observations during other pumping tests.

3.1 Checks for Shallow Groundwater Above the Rustler Formation

Groundwater was not encountered in the Dewey Lake or Gatuña Formations. At a depth of 246 ft bgl, in the Dewey Lake, the drillhole was observed for 15 minutes to determine if groundwater was coming into the drillhole. The return air flow did not include moisture, indicating no significant inflow. An electric probe was run into the hole to a depth of 310 ft when the drillhole had reached 314 ft bgl (in the Forty-niner Member of the Rustler Formation), and it did not indicate any water in the drillhole. (The probe could not be run to 314 ft because of the drilling pipe and bit in the hole.)

3.2 Initial Results From the Magenta Dolomite

During drilling of SNL-2, no specific evidence of water inflow, rates, or water levels for the Magenta Dolomite was obtained.

After the Magenta and upper Tamarisk were cored to 372.3 ft on April 30, 2003, the drillhole remained open overnight. On May 1, 2003, the drillpipe and bit were run into the drillhole to a depth of about 328 ft, the start of the cored interval. An electric probe was lowered inside the drillpipe to a depth of 310 ft without encountering water. This level is above the Magenta.

On May 1, 2003, the drillhole was reamed to 372.3 ft and deepened by drilling to 420 ft, which is in the Tamarisk Member. On that same day, SNL-2 was cored from 420ft to 484.9 ft depth, through the Culebra. Water level measurements of May 2, 2003, reflect inflow from the Culebra as well as any Magenta inflow.

SNL-2 was drilled and cored from above the Magenta and through the Culebra with freshwater mist and foam because the drillhole below the conductor casing was enlarging during drilling with air.

3.3 Initial Results From the Culebra Dolomite

On May 2, 2003, water levels in SNL-2 were 311.58 ft bgl after the drillpipe and core barrel were tripped to the bottom of the drillhole at 484.9 ft, but prior to drilling. No samples were taken, and no testing was conducted.

On May 20, 2003, a pump was placed in the casing to develop the Culebra hydrology and remove drilling fluids. Pumping was cycled on and off at relatively low rates (generally about ½ gpm [gallons per minute], but up to 2 gpm), and pump problems limited development to a volume of about 100 gallons. On May 22, SNL-2 was further developed by pumping–recovery cycles, with pumping rates as high as about 6 gpm and as low as about ½ gpm. The total volume pumped is estimated as less than 200 gallons. Steady pumping rates appear to be in the range of about ½–1 gpm.

Beginning in June 2003, static water levels for the Culebra in SNL-2 were regularly measured (Table 3-1) (Siegel, 2003). Water levels are plotted both as measured and corrected for fluid density to a fresh-water-equivalent (FWE). The casing elevation is 3,323.03 ft amsl (Fig. 2-5). The water level increased significantly in September after the well was better developed (Appendix B), probably due to density changes, but no trend should be inferred on this limited data set (Fig. 3-1).

3.4 Observations About the Rustler–Salado Contact

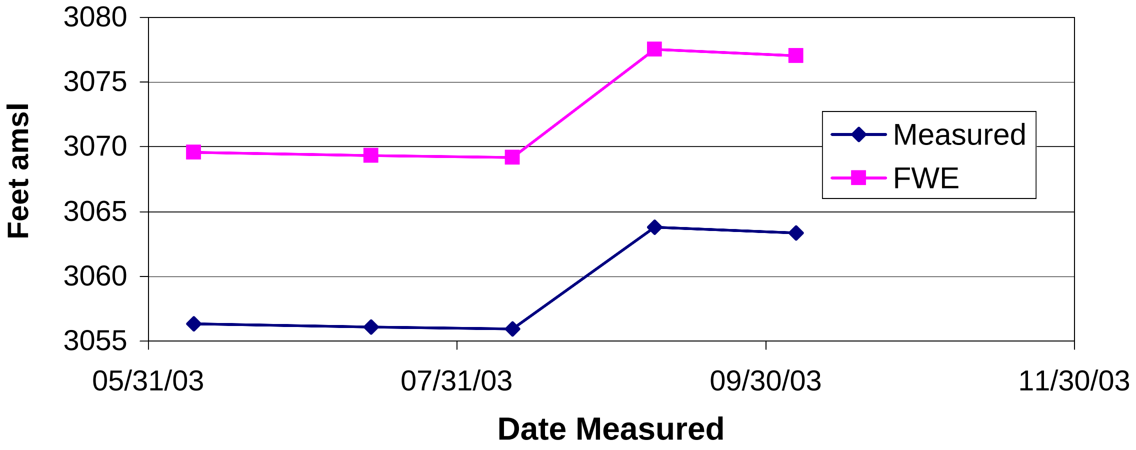
The interval was cored with good recovery. There was no indication during drilling of changes in drilling fluid or of flow into the drillhole from this zone affecting the drilling fluid returns. Cores across the Rustler–Salado contact do not indicate post-depositional dissolution of the upper Salado, and this is consistent with little, if any, water at this zone.

Table 3-1
Water Levels Measured In SNL-2

Date	Time (MD/ST)	Depth (ft) to water level	Water Elevation (ft amsl)	FWE Water Elevation (ft amsl)
06/09/03	9:53	266.70	3056.33	3069.59
07/14/03	10:15	266.93	3056.10	3069.34
08/11/03	8:02	267.08	3055.95	3069.18
09/08/03	10:40	259.25	3063.78	3077.52
10/06/03	10:24	259.68	3063.35	3077.06

Source: Siegel, 2003; no measurement in November 2003 due to instruments in SNL-2
Note that times are U.S. Mountain Zone, either Daylight (D) or Standard (S), based on the season

Figure 3-1
Water Elevation at SNL-2



4.0 SIGNIFICANCE/DISCUSSION

The materials used in completing SNL-2 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 uppermost Salado were cored to obtain direct evidence bearing on the status of dissolution of halite in the uppermost Salado in this vicinity. Along Livingston Ridge, immediately west of the SNL-2 location, Powers (2002a), Holt and Powers (2002), and Powers and others (2003) showed a marked decrease in the thickness of the interval between the Vaca Triste Sandstone Member of the Salado Formation and the top of the Culebra Dolomite Member of the Rustler Formation (Fig. 4-1). Geophysical logs supplied data that indicated the change in thickness occurred because of dissolution of halite at the top of the Salado and that also indicated the SNL-2 location would be little, if any, affected by this process. Holt and Yarbrough (2002) and Powers and others (2003) related this margin to significant changes in the hydraulic properties of the Culebra.

Macroscopic features of the cores across the boundary reveal that depositional cycles are preserved in the uppermost Salado. More clastic-rich beds near the boundary with the Rustler preserve displacive halite crystals as additional evidence of primary sedimentation. There are no unusual accumulations of clastic units, no disrupted sulfates, and no brecciation of the overlying basal Rustler that would be expected to accompany significant dissolution at this boundary. Erosional features in the basal Rustler, similar to those found in large-diameter WIPP shafts, also show that this is a sedimentary accumulation not altered by significant postdepositional dissolution. The premise is that the Culebra at SNL-2 will have hydraulic properties that are mainly related to depth of overburdern, as proposed by Holt and Yarbrough (2002) based on existing Culebra well testing.

Much of the lower Los Medaños in M-1/H-1 is cemented by halite, which also testifies to the lack of vertical movement of fresh water through this section. The uppermost part of M-1/H-1 is probably not cemented by halite, although core recovery was minimal through this zone. Although halite pervasively cements this zone in large poikilotopic crystals, the halite is passive pore-filling cement. There does not appear to be any expansion of the section, either macroscropically or by thickening apparent in geophysical logs. In contrast, some cores from southeast of WIPP show considerable thickening, especially of the upper part of M-1/H-1, with discrete intervals of halite and syndepositional dissolution surfaces at the fresh water/brine interface.

One consequence of passive pore-filling cements such as this is that they could be removed from this interval of the stratigraphic section at other locations, and there may be few, if any, discernible effects at the macroscopic level. There may be no brecciation or collapse, because the fine sandstone remained in grain-to-grain contact, even though cemented. If halite was removed from this stratigraphic interval, halite-filled, vertical to subvertical fractures would likely remain open, and there might be sufficient space for some additional fracturing or block rotation.

Geophysical logs for the area around SNL-2 did not obviously reveal that this interval was halite-cemented, and the margin of halite in M-1/H-1 was placed about 1 mile distant (Powers, 2002a; Powers and others, 2003). This placement of the halite margin in M-1/H-1 will need some adjustment because of the evidence in SNL-2.

The uppermost Los Medaños (M-2/H-2) does not include halite at SNL-2. This is consistent with previous halite margins for this unit and a depositional origin for mudstone-halite facies. The short casing blank placed below the Culebra screen interval was not cemented because there was no halite in the core.

Culebra core recovery was poor through the zones generally believed to be more transmissive. This is a common problem, and not one that is specific to SNL-2. Although no hydraulic testing has been conducted at the time of this report, it is likely that this zone is also the most transmissive for the SNL-2 location by analogy to past experience.

The Magenta core showed little surface porosity or variation during logging that suggest a highly transmissive zone. The most significant deviation is relatively low natural gamma through the middle of the Magenta that corresponds generally to a fractured zone. Detailed neutron plots also show that the zone from about 349–363 ft bgl has somewhat lower neutron flux compared to the upper and lower parts of the Magenta. Nevertheless, the significance of this is unclear, as gypsum within the Magenta is an important factor in neutron absorption. The water level in the drillhole during logging was near the base of the Magenta, and this complicates the resistivity and induction logs.

Cuttings and resistivity changes suggest that the change in natural mineral cements of the Dewey Lake is in the range from 170–184 ft bgl, and this is consistent with a broad trend for this boundary 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, 2003). In the southern part of the site, Powers (2003) hypothesized that this cement boundary provides a perching horizon for natural groundwater. The stratigraphic position of the cement boundary is much higher near the site center (e.g., Holt and Powers, 1990a; Powers, 1997, 2002b, 2003); this part of the Dewey Lake has been removed by erosion at SNL-2.

At SNL-2, neither geophysical logs nor observations during drilling suggest that the Dewey Lake, either above, below, or at the cement boundary, will yield significant water in a drillhole.

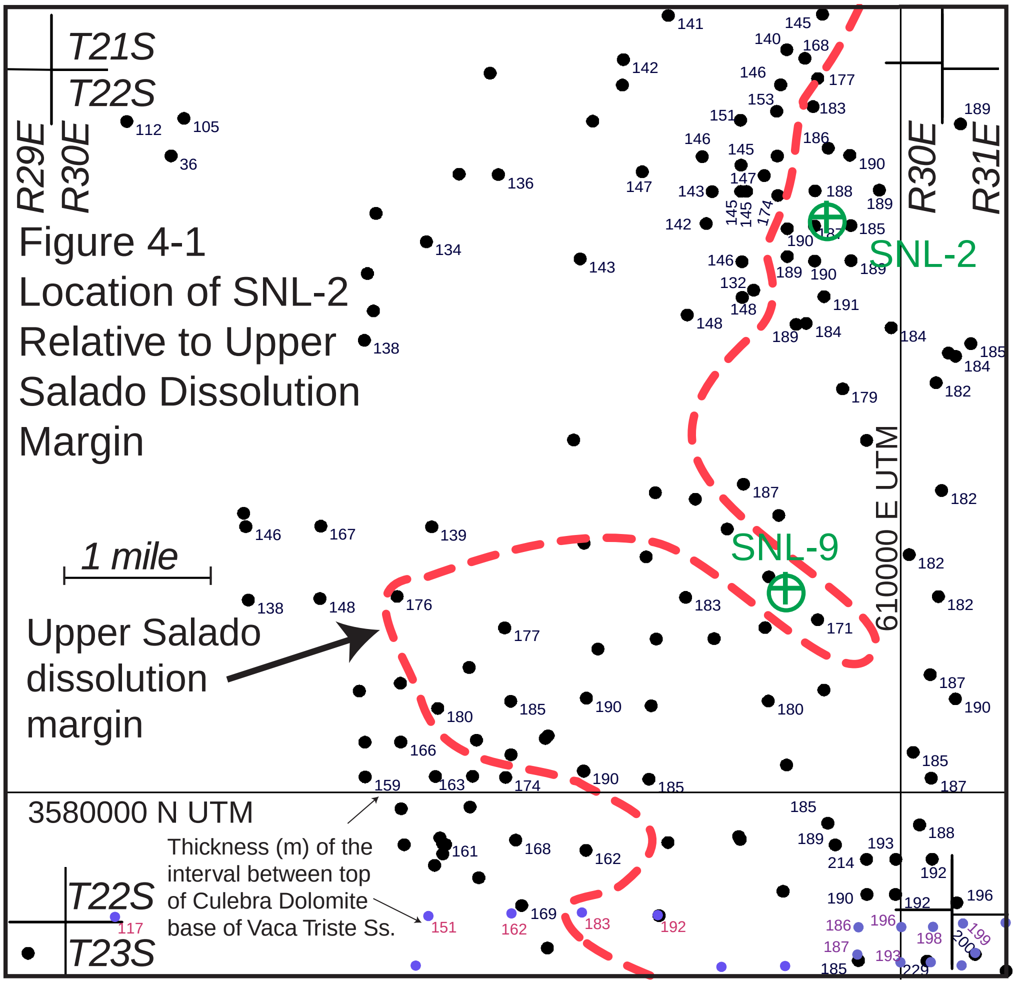


Figure 4-1
Location of SNL-2 Relative to Upper Salado Dissolution Margin

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Appendix A
Drillhole Objectives

The basic document providing the basis for the drillhole and operations is the Program Plan WIPP Integrated Groundwater Hydrology Program, FY03-09 (Revision 0; Sandia National Laboratories, 2003). The main objectives are to resolve questions about water-level changes, provide data for modeling groundwater hydrology, and construct a network of wells to monitor groundwater through the WIPP operational period. Sections of this document relevant to this drillhole have been reproduced on the following pages, with the page number of the section preceding the extract and an ellipsis (…) following the end of the extracted section. One figure has been included, but references and other 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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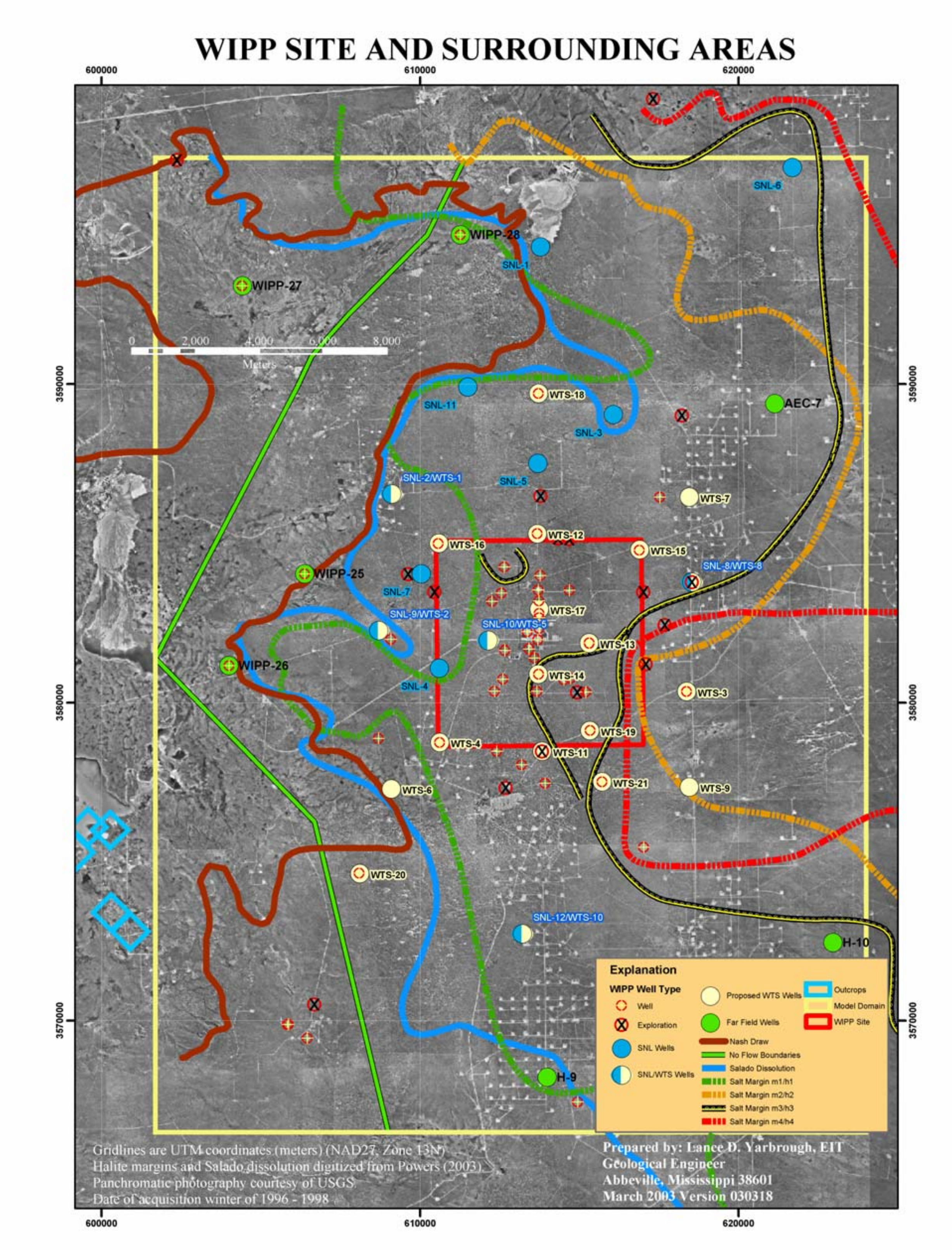

Gridlines are UTM coordinates (meters) (NAD27, Zone 13N)
Halite margins and Salado dissolution digitized from Powers (2003)
Panchromatic photography courtesy of USGS
Date of acquisition winter of 1996 - 1998

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5. Description of Field Activities

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

5.1 New and Replacement Wells

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

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5.1.1 SNL Well Justifications…

SNL-2/WTS-1: Both Culebra and Magenta (and possibly Dewey Lake) wells will be drilled at the SNL-2 location, which is due northwest of H-6 on the Livingston Ridge surface next to Nash Draw and slightly east of the inferred margin of upper Salado dissolution (see Figure 8). This location is west of the m1/h1 halite margin, and wells drilled west of this margin have shown high Culebra transmissivity (e.g., H-6). H-6 is a location where Culebra and Magenta heads are similar and rising at equal rates (Figure 3) even though we have abundant evidence that the Culebra and Magenta are not hydraulically connected at that location. Heads at H-6 are also rising faster than at most other locations. The SNL-2 location is also surrounded by a cluster of oil wells. The purposes of the SNL-2 wells are:

1. determine if dissolution of the upper Salado is extending beneath Livingston Ridge at this location;
2. determine whether hydraulic properties are consistent with dissolution propagating from Nash Draw to the southeast toward the WIPP site;
3. determine how well-connected the Culebra and Magenta are upgradient of the WIPP site on the edge of Nash Draw;
4. determine if flow at this location is toward, or away from, the WIPP site; and
5. provide a monitoring location for a large-scale (multipad) pumping test (centered at SNL-5) to provide transient data for calibration of the Culebra model north of the WIPP site.

In addition, a Culebra well at the SNL-2 location will provide needed information to help define the direction and rate of groundwater flow across the WIPP site, which is required for annual HWFP reporting to NMED (hence the parallel designation WTS-1).

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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-2/ WTS-1		X	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-2/WTS-1	C, M?, DL?	M?		C, M	

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Table 4. Expectations and Contingent Actions for New Wells.

Well	Expectations	Possible Actions if Expectations Not Met
SNL-2/ WTS-1	• moderate to high Culebra T • possible fracturing parallel to Nash Draw • possible dissolution of upper Salado	• combine with information from SNL-11 to revise conceptual model regarding transition from Nash Draw to Livingston Ridge

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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-2/WTS-1	820*	410	??

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Dissolution of the upper Salado Formation will be studied in up to eight drilling locations: SNL-2, 3, 4, 7, 9, and 12 and WTS-4 and 6. At these selected locations, the boreholes that will become the Culebra wells will be cored from the lower part of the upper Tamarisk anhydrite to the halite beds of the upper Salado (approximately 175 ft), and then will be rotary drilled through Marker Bed (MB) 103. If MB100, 101, or 102 are well defined, the on-site geologist together with the Lead Hydrologist and Field Operations Lead may terminate drilling at any one of these marker beds. If MB103 is disturbed by deeper dissolution, the borehole may need to be deepened by an estimated additional 100 ft by rotary drilling through MB109 or other suitable stratigraphic marker bed as determined by the on-site geologist in consultation with the Lead Hydrologist and Field Operations Lead. This decision is most likely for four holes (SNL-2, SNL-3, SNL-11, and SNL-12) where the uppermost Salado may have been dissolved to greater depths, obscuring the upper Salado stratigraphic record. After all desired core and geophysical logs have been collected from the upper Salado, the holes will be plugged with cement back to a depth approximately 20 ft below the base of the Culebra before the upper part of the hole is reamed to its final diameter.

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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 as Central Daylight time. For consistency, all information in the abridged borehole history has been converted to Central Daylight time, regardless of source. Original files are maintained by WRES in the Environmental Monitoring and Hydrology Section.

Note: The abridged drillhole history provided here has been compiled mainly from the daily records produced by personnel of West Texas Water Well Service (WTWWS) and provided to Ron Richardson (Washington Regulatory and Environmental Services). The information has been reformatted and has been modestly edited. *Additions to the record from notes by Dennis Powers or other personnel are in italics.* All times reported in the abridged drillhole history are in 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.

4-28-03 Arrived at site at 08:30 CST (*see note above*). Checked fluid levels on equipment. Conducted safety meeting on heat stress and importance of drinking plenty of fluids. Spudded drilling *pilot hole for surface casing* at 08:50. *Drilled to 34' at 9:15. Took cutting samples at 12', 15', 18', 24', 27', 32' and 33'. Drilled to 62' at 09:32. Took cutting samples at 40', 54', and 61'.* Drilled to 90' of 7 7/8' hole at 09:57. *Took cutting samples at 73', 76', 80', 85', and 90'.* Pulled tools, removed diverter, put on 18" bit, and got rig set up to mix and pump cement. Reamed hole to 18" at 10:20. *Completed reaming 30' blowing hole clean at 12:30. Break for lunch at 12:45.* Pulled tools, ran 30' 13 3/8" *O.D.* casing (Lone Star 48#) at 13:45. Pumped cement and washed out pumps at 14:00. Picked up tools and trash, secured location for evening, and left site at 15:25.

4-29-03 Arrived at location at 07:00. Held safety meeting regarding caution of rattlesnakes. Instructions given to contact plant for removal rather than killing them. Mixed seven sacks of cement (Portland) and topped off at 07:10. Put on diverter and got ready to drill at 07:30. *Added six bags cement to top of surface casing hole.* Cleaned out hole from 30' to 60' at 09:00. Stopped to repair diverter at 09:15. Continued drilling at 09:55. Unable to clean out hole at 45' to 50' due to loose sand. Switched to mist and foam, cleaned out to 90' at 10:05. Continued drilling at 10:30. *D. Powers discarded sample at 100' at 10:40. D. Powers collected sample at 115' (SNL-2-16) at 10:52. Collected sample at 120'-121' (SNL-2-17) at 11:07. Collected sample at 140'-142' (SNL-2-18) at 11:20. Collected sample at 160'-162' (SNL-2-19) at 11:44. Collected sample at 180'-181' (SNL-2-20) at 11:58. Collected sample at 200'-201' (SNL-2-21) at 12:23. Collected sample at 220'-221' (SNL-2-22) at 12:48. Collected sample at 240'-241' (SNL-2-23) at 13:05. Drilled to 260' at 13:36. Drilled to 280' at 13:55. Drilled to 300' at 14:21. Drilled to 314' at 14:30.* Air compressor broke. Tripped drill pipe out of hole at 14:57. Secured location and left site at 17:00.

4-30-03 Arrived at location at 07:30. Conducted safety meeting regarding policing area. Instructions given to keep all work areas free from debris and trash and to keep all tools picked up and stored properly. Tripped tools into hole and prepared for drilling operations at 07:45. *Ran electric probe down hole; no water indicated.* Switched out air compressors at 08:20. Started drilling and cleaning hole at 08:50. *D. Powers collected sample at 320'-321' (SNL-2-29) at 09:02. Collected sample at 325' (SNL-2-30) at 09:09. Collected sample at 328' (SNL-2-31) at 09:18.* Stopped drilling, came out of hole, prepared to core, and picked up trough to lay down cores at 09:20. Down waiting on core company (Dowdco) at 10:00. Dowdco arrived on location at 10:50 and made up core barrel. Started in hole with core barrel and drill pipe at 12:05. Started coring with 30' core barrel *from 328'* at 13:03. Pulled tools and laid out core at 13:47. *End of* core *run.* Recovered 29.2' of core (SNL-2-32). Assembled tool and returned to hole at 14:43 *to collect additional 15' – did not get* *base of the Magenta Dolomite.* Continued coring operation at 15:16. Cut additional 15' of core. Tripped coring tools out of hole and put core in trough to 372.3', and assembled coring tool at 15:48. *Full core recovery; boxed 15.1' core.* Cleaned up location and prepared for next day's operations at 16:45. Secured and left site at 17:00.

5-01-03 Arrived at site at 07:00. Checked fluid levels in rig equipment. *Reamed cored section at 07:50.* Conducted safety meeting regarding vehicle safety, fire extinguishers, and first aid kits, and reviewed emergency numbers at 08:00. *Measured water level; probe down to 310' - no water detected.* Tripped drill pipe with bit into hole at 08:10. Reamed out area from 310' to 373' at 08:20. Drilled 7 7/8" hole from 373' to 420'. *Collected sample at 380'-381' (SNL-2-46) at at 09:04. Collected sample at 400'-401' (SNL-2-47) at 09:24. Collected sample at 420' at 09:54.* Tripped drill pipe and bit out of hole and picked up 30' core barrel. Returned to bottom with core barrel and cut 30' core (27') at 11:00. Tripped out of hole to lay out core at 11:50. *End of core run. Collected sample (SNL-2-49) at 12:20.* Down for lunch at 12:45. Assembled *double* core barrel *(60')* and returned to hole at 13:10. Cut 22.6' core at total depth of 471' at 14:54. Unable to cut 60' core as planned due to jammed core barrel. Tripped out of hole and laid out core at 15:32. *Core barrel at surface approximately 23' of core at 16:10. Placed core in tray at 16:30.* Only retained 15.4' *of 22.6'* core. Assembled core barrel and tripped back to bottom of hole at 16:41. Cut 13.6' core at 17:40. Core barrel jammed with gummy black clay. Tripped core barrel out of hole at 18:14. Total depth at quit time was 484.9'. Roughly 8.6' of core retained out of 13.6' cut. Assembled core tube and picked up tools at 19:00. Left site at 19:25.

5-02-03 Arrived at site and met IW Transports with brine water at 07:05. Conducted safety meeting regarding heat stress and importance of drinking plenty of fluids. Tripped drill pipe and core barrel to bottom at 07:20. *Measured fluid level in hole at 311.58' (= 318' – 6.42') at 08:18. (Note: foam from drilling standing in wellbore affecting fluid level measurements.) Cleaned out hole at 08:30.* Began coring and cut first 30' at 09:26. Continued coring and cut additional 11' before core barrel jammed at 10:45. *Environmental compliance (Zybok/Stockwell) on site at 11:05.* Tripped out of hole and retained only *22.4'* of total 41'. Tripped core barrel back into hole at 12:06. Stopped for lunch at 12:50. Finished preparations for coring at 13:10. Began coring operation at 13:17. Cut 15.8' before core barrel jammed at 540.1'. Tripped tools out of hole and laid out core at 14:14. Retained 14.8'. Assembled core barrel, mixed cement, and poured cement around bottom of diverter to stop air escaping at 15:58. Stopped operations for weekend and left site at 16:30.

5-03-03 No drilling activity.

5-04-03 No drilling activity.

5-05-03 Conducted safety meeting (in Odessa) regarding prevention and treatment of heat exhaustion. Arrived at site at 08:15. Tripped core tool and drill pipe into hole and cleaned out bottom at 10:00. *Measured water level at 281.13' (= 287.55' – 6.42') at 11:15.* Started coring *at 540'* at 12:25. Cut 35' before core barrel jammed. Tripped core barrel and drill pipe out of hole at 13:37. *D. Powers collected a cuttings sample at 577.0'.* Laid core out at 14:35. *Good recovery; bottom barrel had almost 100%; top barrel had approximately 4'-4.5' only.* Retained *total of* 34.5' of core. *Total depth now estimated at 577'. (Core depth initially incorrectly marked showing 572' at end* *of core run; revised before photographing and boxing.)* Assembled core barrel, ran pipe back to bottom, and began coring again at 15:19. S*topped making progress and decided to come up out of hole at 15:50.* Cut and retained 6.5' of core. *Placed core in tray at 16:20.* Assembled core barrel at 16:40. *Boxed core at 17:00.* Left site at 17:25.

5-06-03 Arrived at site and conducted safety meeting regarding forklift safety at 07:00. Tripped drill pipe into hole at 07:15. Checked static water level at 334.58' *(= 341' – 6.42') at 07:35*. Unloaded and cleaned out hole to bottom at 07:46. Began coring at 08:44. Cut and retained 29'. Tripped out of hole and laid core in tray at 09:20. *End of core run.* IW Transport brought load of brine and sucked out load from pit. Dowdco loaded equipment – through coring at 11:00. Tripped drill pipe back into hole and started reaming (top at 420'). *Attempted to estimate amount of water hole made under steady pressure.* Stopped jetting well at 411'. Jetted for 10 minutes. *Well yielded consistent ≈ 15 gpm for a full 10 minutes with no decrease in rate.* State Engineer's office inspected casing. Reaming hole at 12:30. Unable to make a connection; hole unstable. Pulled out of hole. Removed diverter from rig at 14:15. Contacted Rick Beauheim at WIPP at 14:30. *R. Keith recommended going to brine gel (bentonite/brine water solution) as drilling fluid. R. Beauheim did not want brine gel because it would slow down development phase of well completion. He (Beauheim) recommended Flowzan (a polymer surfactant) added to brine. R. Keith acknowledged that Flowzan might work but there was a high probability that the hole would continue to cave and could be lost. D. Powers suggested we terminate drilling and log the well because the basic geologic information from the upper Salado had been obtained. After logging, the hole could be plugged back to below Culebra and reamed for casing. All present agreed that was the best solution. The reaming will be accomplished by using Flowzan. Notified environmental compliance of decision to use Flowzan and brine at 15:00.* Prepared for next day's operations. Fenced pit at 15:30. *Received concurrence to use Flowzan from Steve Travis, Environmental Compliance, and Stewart Jones, Environmental Monitoring and Hydrology, at 16:45.* Left site at 17:30.

5-07-03 Arrived at site at 07:15. Held safety meeting regarding traffic on roads adjacent to location. Prepared to run geophysical logs at 07:25. Ran caliper log; hole open to 517'. Ran nine more logs with one tool at 08:30. Ran additional logs at 09:20. Serviced WTWWS portable pits and continued logging at 13:20. Completed logging at 15:20. Reviewed logs with D. Powers and R. Richardson at 15:40. Tripped into hole with drill pipe at 16:25. Mixed ~ 1 cubic yard of cement (Portland). Pump plug at bottom of drill pipe at 517'. Began pumping at 17:05, and pumped 25 sacks. Tripped drill pipe out of hole from 17:12 to 17:35. Washed cement out of mud pump at 17:35. Cleaned up location and left site at 18:00.

5-08-03 Arrived at site at 08:00. Conducted safety meeting regarding handling brine water. Tripped drill pipe into hole at 08:10. Tagged cement at 510'. After discussion, mixed half tub of cement (16 sacks). Prepared to pump cement at 08:55. Pumped cement plug at 09:30. Tripped drill pipe out of hole at 09:35. Cleaned cement from pump and hoses. Rigged up portable mud system at 10:00 to 11:30. IW Transport brought one load of brine and vacuumed out dirt pits. Stopped for lunch at 11:30. Greased rig at 11:45. Left site at 13:15.

5-09-03 to 5-11-03 No drilling activity.

5-12-03 Arrived at site at 08:30. Held safety meeting regarding electrical safety. Extended electrical cable and positioned auxiliary generator away from rig at 08:40. Started reaming hole to 12 ¼” at 10:05. Reamed from surface to 334'. Tripped drill stem out of hole at 18:05. Filled hole with fluid at 18:30. Shut down for evening and left site at 18:35.

5-13-03 Arrived at location at 07:15. Checked oil level in engine. Held safety meeting regarding personal protectiveequipment at 07:23. Tripped drill pipe into hole and began reaming at 334' at 07:30. Milltooth bit was not cutting anhydrite section very well. Tripped out of hole at 10:20 and switched to button bit. Continued reaming at bottom of hole at 12:00. Reamed to 410'. Broke down at 13:30. Clutch plates and 1 pneumatic hose to be replaced. Started rig at 14:21 and circulated fluid in hole until parts arrived from Odessa at 16:00. Contacted geophysical logger and put on stand-by until rig fixed. Mechanic arrived on site to repair WTWWS rig at 16:00. Completed repairs at 17:35. Circulated hole. Tripped tools out of hole at 17:50. Left site at 18:30.

5-14-03 Arrived at site at 07:00. Held safety meeting regarding vehicle safety and maintenance. Tripped drill pipe into hole at 07:10. Began reaming at 410' at 07:40. Finished hole at total depth of 489' at 14:35. Circulated hole, laid down drill pipe, and prepared to run caliper log. Rigged up logger to run caliper logs at 15:40. Ran caliper log to 489' at 15:50. Prepared for next day’s operations (casing) at 16:05. IW Transport delivered one load of brine. Left site at 16:30.

5-15-03 Arrived at site and checked fluid levels in engine at 07:00. Held safety meeting at 07:15 regarding hazards of high winds and blowing dust. Tripped drill pipe *with bit* into hole *to clean out bottom of hole* at 07:20. Water level measured at 40.3' from surface. Circulated hole at 08:05. *Estimated* 30' of fill in bottom of hole. *Conversation with driller at 09:30: R. Keith noted that the hole is filling in and advised that in order to keep from losing the hole, the casing and cement should be run as soon as possible. Contacted S. Jones and D. Lynn at 09:35. Asked them to notify the state engineer to come out at 17:00 to witness cementing the hole. Received confirmation from D. Lynn at 09:50.* Tripped pipe out of hole at 09:40. Started running tremmie pipe at 10:28. *Rigged up to run casing at 10:40. Began running casing at 11:20. 7.23' blank casing below 27.91' of slotted screen. Placed centralizer on joint between blank and screen interval at 11:28.* Placed centralizers *on couplings* every 40'. *Placed last joint of casing in hole at 12:39. Shortened casing by taking 18.13' off top.* Flushed hole with brine water and cleaned out heavy mud at 14:15. Pumped 24 sacks of 8/16 (Brady) silica sand at 14:35. Filled hole from bottom at 489' to 5' above screen (that would be at 447.09'). Pumped 4 sacks (50# each) of fine sand from 447.09' to 442.09' at 15:23. Plugged hole with 3 bags (50# each) of bentonite from 442.09' to 437.09' at 15:30. *Mike Stapleton of the state engineer’s office on site to witness cementing the casing.* Stopped to wait on cement at 17:00. Pumped 12 yards cement grout from 18:12 to 19:05. *Pulled two joints after first load pumped down at 18:46. Began pumping second load of cement down hole at 19:00.* Pulled tremmie pipe and washed equipment at 19:05. Topped off cement at surface at 19:40. Cleaned up at 19:45. Left site at 20:00.

5-16-03 Arrived on site at 07:45. Held safety meeting. Ran 2 $^{1}/_{16}$" tubing into hole at 07:55. Rigged up to pump fresh water to clear out perforations. Sent truck after fresh water at 08:20. IW Transport on site to vacuum pits. Did maintenance on rig. Started rigging everything down and getting ready to move. *Reported water level at 144' below top of casing upon arrival at site. Tagged* *cement in conductor casing, and was ~ 2 ft down. Prepared to flush well casing with fresh water to clean screen out at 10:30.* Flushed well with 50 barrels of fresh water *until running clear; approximately 15 minutes*. Loaded portable pit system to be moved to SNL-9 at 12:06. Handed off 2 loads of brine and mud to disposal. Continued moving equipment and rig to SNL-9. Left site at 18:30.

5-17-03 Arrived on site at 07:45. Held safety meeting regarding slips, trips, and falls. Loaded equipment to move to SNL-9. Poured 3' x 3' slab with 7 bags of Ready-mix at 11:00. Left site at 12:30.

5-20-03 *WTWWS is on site and started pumping by 08:15. Well is only making an estimated 2 gpm, and water is still muddy. Well draws down quickly, and it was shut off at 08:40 to recover; well may only be making 1/2 gpm at this time. Generator was replaced. Well was pumped from 11:00 to 11:30, and then was allowed to recover. Pumping began again at 13:15 at highest rate for ~ 10 minutes, producing about 40-50 gallons before drawing down to pump intake. Pump was shut off from 13:30–13:50. Started pumping at about 1/2 gpm at 13:50; cycled pump on and off until 15:00. Water became clearer, but yield is low. Pump motor failed and was removed from well.*

5-22-03. *Arrived on site 09:05, set up generator. Began pumping at about 5-6 gpm and continued for about 11 minutes, with water clearing up after initial muddy stage. Flow decreased to about 4 gpm for an additional 6 minutes. The flow valve was opened fully at 09:42, increasing flow to 8–9 gpm. The water became a little muddy, and the fluid level was pumped down to the intake in less than 1 minute. The pump was shut off to allow water levels to recover. Pump was turned back on at 09:47 and pumped steadily at 3–5 gpm for about 1 minute. The valve was partially closed to restrict flow to about 1 gpm for 11 minutes. At 11 minutes, the head was probably at the pump intake; pumping continued to 10:01. Pump was stopped at 10:01. At 10:05, the pump was restarted at about 4 gpm for less than 1 minute; pumping continued to 10:09. Will continue to cycle the pump to surge the well and sand pack. Pump turned on at 10:24 at 1–2 gpm initially with steady flow of 1–½ gpm until 11:00. Water was intially cloudy, then cleared. Pump was turned off from 11:00–11:15. Pumped about 4–5 gpm for a couple minutes, with water staying fairly clear. Will cycle pump a couple more times.*

5-24-03. *Removed pump from well.*

8-26-03. *Arrived on site 10:15 with Bentle's well service and set up work over rig for bailer. Collected 10 bailers full of red muddy water by 11:30. Surging well by pulling bailer fast. Bailed 15 bailers full by 11:45. Eighteenth bailer empty but with chunk of Dewey Lake sandstone in bailer. Allowed well to recover from 12:00 to 12:10. Two additional bailers with red muddy water with red silt and debris; allowed well to recover from 12:15 to 13:30. Resumed bailing; 5 bailers with debris. Tagged hole total depth of 484 ft below top of casing at 15:00; more debris removed. Pulled 6 additional bailers by 15:30; water beginning to clear. Will install pump in the morning.*

8-27-03. *Arrive on site at 10:00 to set pump. Measured joints and set pump for 481.07 ft below top of casing. Began pumping at 12:15 with steady stream of about 10 to 12 gpm of fairly clear water. Flow dropped to about 1½ gpm clear water at 12:35 and well pumped down by 12:40. Allowed well to recover to 12:52; pumped until 12:55 at about 8 to 10 gpm. Pumped from 12:55 to 13:02 at about 1 gpm. Allowed well to recover from 13:02 to 13:35. Pumped at about 2 gpm from 12:35 until 14:15, with well clearing up and very low flow. Allowed well to recover from 14:35 to 14:50. Pumped from 14:50 to about 15:30 with flow of about 2 gpm; water flow steady and clear. Stopped pumping at 15:30 with water level down to near pump intake.*

8-28-03. *Arrived at SNL-2 at 10:30. Pulled pump from well and left site at 15:00.*

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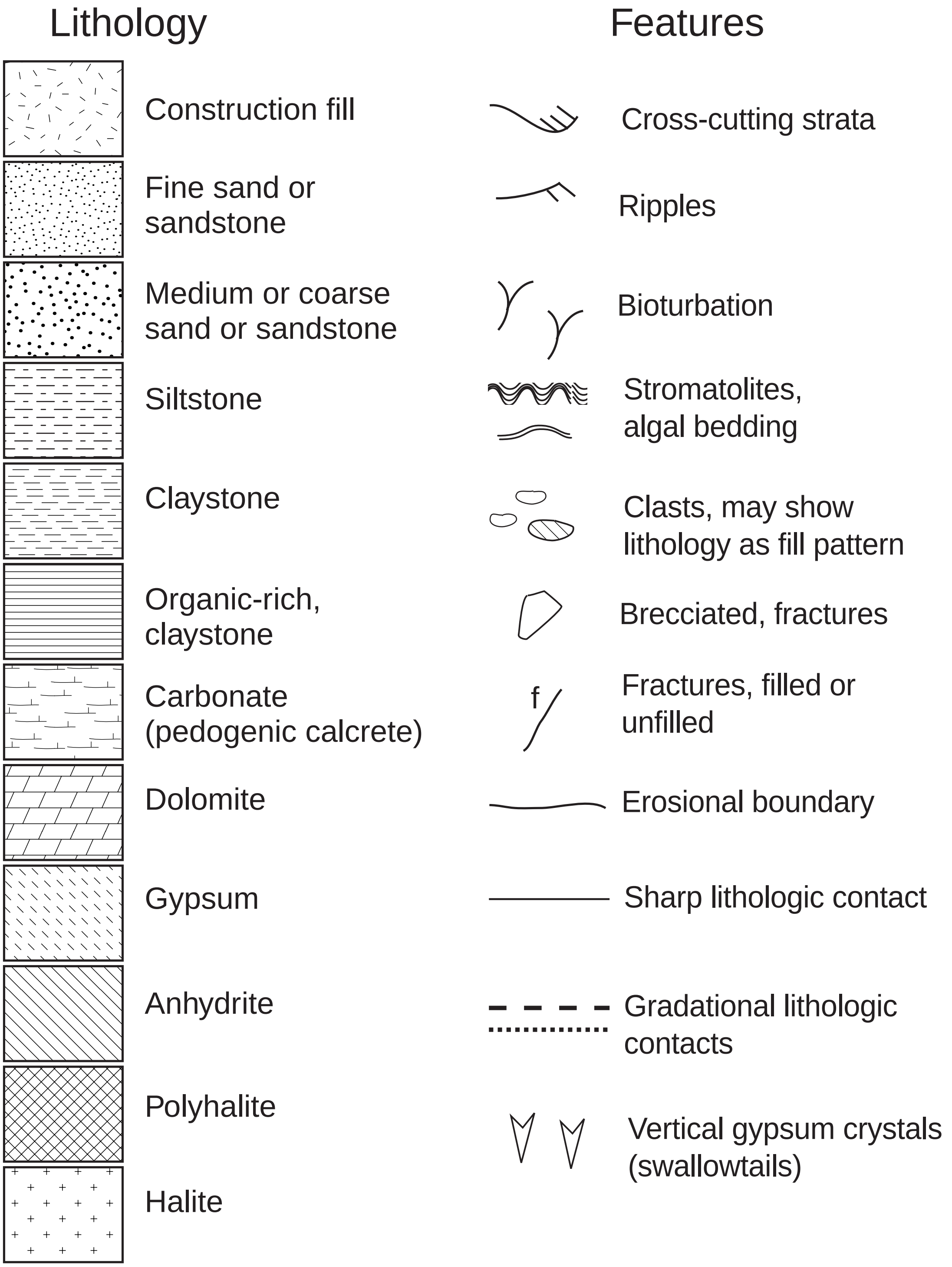
Appendix C
Geologic Logs

Note: The original field descriptions and graphic logs were prepared at somewhat variable 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. For publication purposes, the figures were reduced to ~93% of the original size, and the scale indicated will be incorrect. The vertical footage log is reduced proportionally and will still be correct.

The field descriptions were related to depth based on drilling informaiton 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; some may not be used in this report.

CORE LOG

Sheet 1 of 7

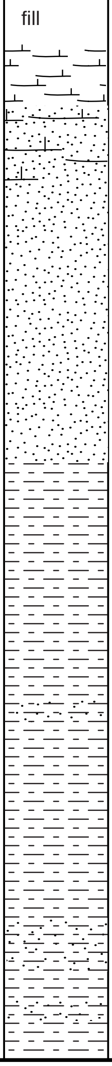
Hole ID: SNL-2
Location: 574 ft fnl, 859 ft fwl, section 12, T22S, R30E

Drill Date: 4/28/03-5/6/03
Drill Crew: West Texas Water Well Service (Ronnie Keith, driller)
Drill Method: rotary
Hole Diameter: initial 7.875 inches
Hole Depth: TD 614 ft
Hole Orient: vertical downward
Drill Make/Model: Gardner-Denver 1500
Barrel Specs: 4 inch i.d.; 6.5 o.d.
Drill Fluid: air to 90.5'; foam to 485'; brine & foam
Core Preserv: marked and boxed at site

Logged by: Dennis W. Powers, Ph.D., Consulting Geologist
Date: 4/28/03
Scale: 1":10'; 1":20'

	Northing	Easting	Elevation
Survey Coordinate: (Ft)	514022.03 NM SP (NAD27)	652348.94 NM SP (NAD27)	3320.87 ft amsl (surface benchmark)

Comments: This well is also known within the project as WTS-1; the State Engineer assigned the number C-2948. The reference elevation for coring and drilling is ground level. Differences in stratigraphic intervals compared to geophysical logs derive mainly from uncertainties during drilling and from core recovery. Core depth marks were based on best estimate of recovered depths.

Run Number	Depth (feet)	% Recovered	RQD	Profile (Rock Type)	Description	Remarks
N/A	0	cutting sample depths noted N/A	N/A		0-3' Construction fill, sand to ~ 3 ft	
					3-7' Mescalero caliche; ss, very calcareous, silty.	
					Top of Gatuña Formation	
	10	12 15 18			7-30' Sandstone, fine-medium grained, light reddish-brown (2.5YR6/4); well indurated; moderately well sorted and rounded; carbonate content decreases downward to about 27 ft, more argillaceous below 27 ft.	
	20	24-25 27-28				24 ft @ 8:05a MDT
	30	32 33			30-33' Siltstone, sandy, red (10R5/6); very calcareous; micaceous; green siltstone; MnO_2 stains.	33 ft @8:15a MDT; add jt
					33-40' Siltstone, argillaceous; reddish-brown (2.5YR5/4-4/4), slightly calcareous	
	40	40			40-52' thin hard-drilling zone @ 40 ft Sandstone, argillaceous, very calcareous; fine to medium grained, angular to subangular; 3-5% opaques at about 40 ft; becomes silty, friable, moderately calcareous to 52 ft, pink (5YR7/3); very fine cuttings, no samples retained in interval.	
	50	54			52-90' thin hard-drilling zone @ 52 ft and 57 ft. Sandstone, argillaceous, light reddish brown (2.5YR6/4), very fine-medium sand, angular, w/ ~ 5% opaques; interbedded with siltstone, argillaceous, sandy, moderately calcareous, friable.	
	60					

Hole ID: SNL-2

CORE LOG
(cont. sheet)

Sheet 2 of 7

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

Date: 4/28-29/03

Run Number	Depth ( )	% Recovered	RQD	Profile (Rock Type)	Description	Remarks
	60	61 cutting sample depths noted				62 ft @ 8:35a MDT add joint
	70	73 76			thin hard-drilling zone @ 70 ft.	
	80	80				
		85				90.5 ft @ 8:57a MDT stop drilling, ream upper 30 ft, place 12.5 inch i.d. conductor casing
	90	90			cuttings returns from ~ 90-105 ft mainly caliche, Gatuña clasts after reaming and placing conductor casing	Begin drilling 4/29/03 with Baroid Quick Foam because of hole conditions 40-50 ft bgl
N/A		N/A	N/A			
	100					100 ft @ 9:40a MDT
					105 ft: approximate top of Dewey Lake Fm	
					105-277' Sandstone, argillaceous, red (10R4/6), slightly calcareous; small (~0.05 inch) round, gray (light olive brown: 2.5YR5/4) reduction spots. Dark brown, thin (<< 0.05 inch) laminae. Interbedded with siltstone, sandy siltstone, sandy claystone.	
	110					
		115				
	120	120-121				120 ft @ 10:05a MDT
	130					
	140					140 ft @ 10:19a MDT

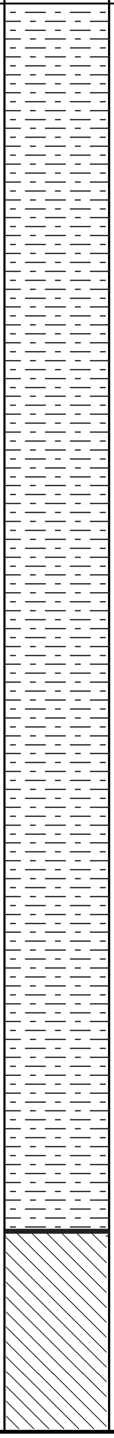
Hole ID: SNL-2

CORE LOG
(cont. sheet)

Sheet 3 of 7

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

Date: 4/29/03

Run Number	Depth ( )	% Recovered	RQD	Profile (Rock Type)	Description	Remarks
N/A	140	140-142 cutting sample depths noted N/A	N/A		Note graphic scale change thin hard-drilling zone @ 145 ft.	150 ft @ 10:26a MDT add joint
	160	160-162				160 ft @ 10:43a MDT
					cuttings returns from ~ 170 ft include observable gypsum; not very calcareous below this zone	
	180	180-181			105-277, cont: Sandstone, argillaceous, red (10R4/6), slightly calcareous; small (~0.05 inch) round, gray (light olive brown: 2.5YR5/4) reduction spots. Dark brown, thin (<< 0.05 inch) laminae. Interbedded with siltstone, sandy siltstone, sandy claystone.	180 ft @ 10:57a MDT add jt @ 183 ft
	200	200-201				200 ft @ 11:23a MDT
	220	220-221				220 ft @ 11:48a MDT
	240	240-241				240 ft @ 12:04p MDT add jt @~ 246 ft
	260	260-261				260 ft @ 12:36p MDT
					Base of Dewey Lake Formation @ 277 ft bgl Top of Rustler Formation, Forty-niner Mbr	278 ft @ 12:46p MDT add jt
	280					280 ft @ 12:55p MDT harder drilling
		293-294				
	300					300 ft @ 1:21p MDT

Hole ID: SNL-2

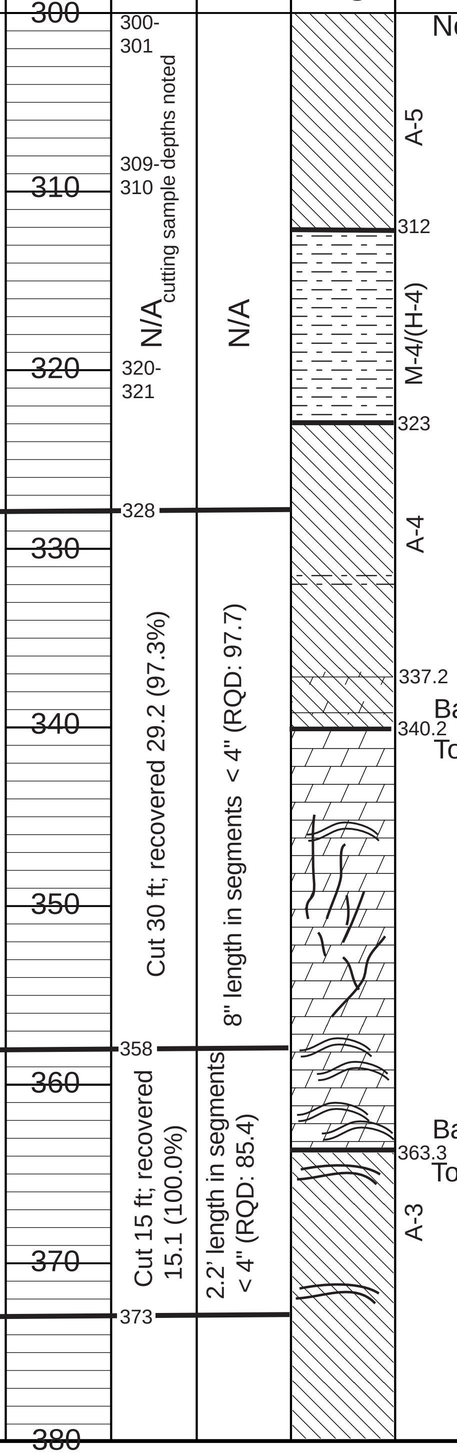
CORE LOG
(cont. sheet)

Sheet 4 of 7

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

Date: 4/29/03-5/1/03

Run Number	Depth ( )	% Recovered	RQD	Profile (Rock Type)	Description	Remarks
N/A	300–328	300-301 309-310 320-321 N/A cutting sample depths noted	N/A		Note graphic scale change Gypsum white (10YR8/1); fine grained. Claystone, silty, and siltstone, red (2.5YR4/6;wet), soft, non-calcareous Gypsum, white to clear, coarsely crystalline (from cuttings).	310 ft @ 1:30p MDT add joint 314 ft @ 1:40p MDT compressor down; end drilling 4/29/03 4/30/03 no water in hole; resume drilling 320 ft @ 8:00a MDT
Core Run 1	328–358	Cut 30 ft; recovered 29.2 (97.3%)	8" length in segments < 4" (RQD: 97.7)		Gypsum and anhydrite, white to gray; mainly fine to medium crystals, wavy bedded. Includes numerous thin (< 0.2 in) veinlets of fibrous gypsum; fibers perpendicular to bedding. Siltstone, brown @ 331.9-332.1 ft. Dolomite interbeds 337.2-340.2 ft. Base of Forty-niner Member Top of Magenta Dolomite Member Dolomite, gypsiferous, mainly light brown (2.5Y8/2-white; 2.5Y7/2 -light gray) with zone of reddish brown (10R6/1 - pale red) from 359.2-359.8 ft. Wavy bedded, with some lenticular bedding. Algal laminae throughout, dominant from 345-346 ft, 363.3-358 ft. Fractures from ~45^o to vertical from 344-357 ft; some with fibrous to fine gypsum. Some fractures w/o apparent aperture. Some blocks slightly rotated. No apparent porosity. RQD is poor from 357.5-359.1 ft, 361.5-362 ft.	328 ft @ 8:18a MDT; prepare for coring; start coring @ 12:03p
Core Run 2	358–373	Cut 15 ft; recovered 15.1 (100.0%)	2.2' length in segments < 4" (RQD: 85.4)		Base of Magenta Dolomite Member Top of Tamarisk Member Anhydrite and gypsum, light gray, fine to coarsely crystalline; laminar zones @ 364-365 ft, 368.5-368.9 ft. Somewhat finer grained below 369- ~371 ft. Laminar bedding, possible organic matter 371-372 ft.	358 ft @ 12:45p MDT
	373–380				Gypsum and anhydrite; cuttings mixed with higher units	373 ft @ 3:15p MDT; end drilling 4/30/03 5/1/03 ream cored section; begin drilling 7:50a MDT; Baroid Quick Foam



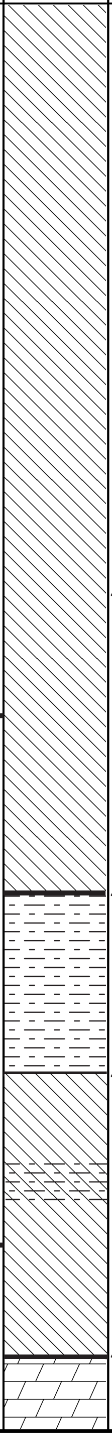
Hole ID: SNL-2

CORE LOG
(cont. sheet)

Sheet 5 of 7

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

Date: 5/1/03

Run Number	Depth ( )	% Recovered	RQD	Profile (Rock Type)	Description	Remarks
N/A	380 390 400 410	380 N/A cutting sample depths noted 400	N/A		A-3 cuttings mixed 413 thin zone of easy drilling @ 413	380 ft @ 8:03a MDT 400 ft @ 8:23a MDT 403 ft @ 8:29a MDT add jt
Core Run 3	420 430 440	420 Cut 29.6 ft; recovered 28.6 (96.6%)	2.3' length in segments < 4" (RQD: 92)		420-425: Gypsum and anhydrite, fine to coarse, with subhorizontal bedding; gypsum-filled fractures @ ~60^{o} from vertical spaced 4-8 inches. 425-430.2: Gypsum, gray, brecciated, with gray siltstone/claystone between clasts. Well indurated. Clasts & mix w/reddish-brown siltstone indicate some early post-depositional and later movement. 430.2 M-3/(H-3) Claystone, sandy, reddish-brown (2.5YR4/4); bedded on ~1 inch scale. Subhorizontal gypsum veinlets w/vertical fibrous gypsum spaced 1-2 in. Coarser gypsum in 0.5 inch fillings, spaced 8-12 inches, of veins @ ~ 45^{o} angle; these post-date subhorizontal veins. Slickensides on some subhorizontal fractures. 439.5 A-3 441-445: Gypsum, gray, with reddish brown outlines of bedding, crystal boundaries 445-448.6: Anhydrite, gypsum, gray, subhorizontal bedding, some possible nodular fabrics. Argillaceous zone 445-447 ft. Subvertical fractures in argillaceous zone are filled with gypsum. Some discing of core at top of run 4. Coarse gypsum in fractures increases downwards towards top of Culebra.	420 ft @ 8:54a MDT; prepare for coring
Core Run 4	450 460	449.6 Cut 22.6 ft; rec 15.6 (69%)	3.5' length in segments < 4" (RQD: 77.6)		455.7 Base of Tamarisk Member Top of Culebra Dolomite Member	373 ft @ 3:15p MDT; end drilling 4/30/03 5/1/03 ream cored section; begin drilling 7:50a MDT; Baroid Quick Foam 380 ft @ 8:03a MDT

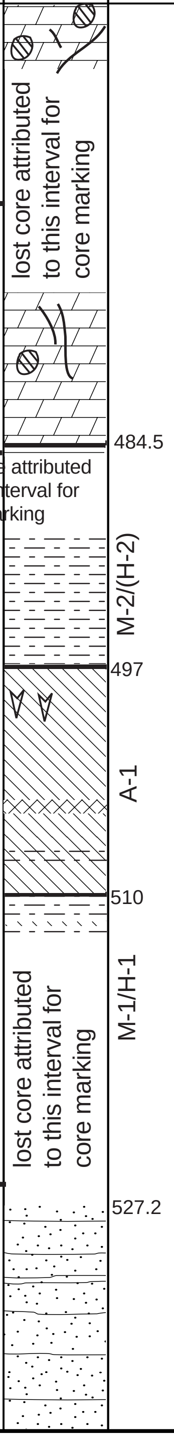
Hole ID: SNL-2

CORE LOG
(cont. sheet)

Sheet 6 of 7

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

Date: 5/1-2/03



Run Number	Depth ( )	% Recovered	RQD	Description	Remarks
Core Run 4	460 470	see note 471.2		Dolomite, silty, with some gypsum-filled vugs. Yellowish-brown (10YR5/4) from 462.8-463.4 ft, moist. Dark grayish brown (10YR4/2 wet) from 456.7-462.8 ft, with organic black zone at top. Open vugs generally < 0.5 inch diameter. High-angle fractures with and w/o gypsum filling. Gypsum-filled vug ~ 1 inch diameter @ 459 ft. Open vugs to 1 inch @ 462.2. All recovered core attributed to upper part of interval, as core above Culebra is generally intact and continuous.	Note: interval for run 4 incorrectly added in field; base should have been 472.2 ft. stopped making progress 471.2 ft (472.2 ft) @ 2:35 p MDT; pull core barrel
Core Run 5	480	Cut 13.9 ft; rec 9.0 (64.7%) 485.1		Recovery from run 5 was marked assuming recovery was from the bottom of the cored interval. Geophysical logging showed base of Culebra higher than marked. Dolomite, gypsiferous, with subvertical fractures that are partially gypsified. Low porosity from 476.1-479.3 ft, very porous (small, < 0.05 inch) from 479.3-484. Claystone, black, sticky; laminae ~ 0.05 inch thick.	Note: Core run 5 marked assuming full recovery of core bottom; geophysical logs indicate lost core 485.1 ft (486.1); end drilling 5/1/03; begin 5/2/03; switched to brine w/foam
Core Run 6	490 500 510 520	Cut 41 ft; recovered 22.4 (54.6%) 526.1	lost core attributed to this interval for core marking 2.3' length in segments < 4" (RQD: 82.1)	Siltstone, argillaceous, very calcareous. Gray (7.5YRN6) to 491.6; weak red (2.5YR4/2) mottled gray from 491.6-498. Bedding up to 1 inch thick; scattered gypsum blebs, horizontal gypsum veins; few fibrous gypsum veins ~35-45^{o} from vertical. Clasts of gypsum from 495.5-497. Anhydrite, fine crystalline, gray, some pinkish polyhalite(?) ~505. Some high-angle fractures, mainly healed. Some pores along subhorizonal zones - may be along vein fillings. Laminar to wavy bedding from 0.05-0.5 inch; tiny possible swallowtail gypsum ~ 500 ft. Stylolite(?) at 498.5 ft. Claystone, silty, slightly calcareous, from 507.3-508.4, w/small gypsum clasts (graded?) from 508-508.4. Basal anhydrite is laminated, about 0.07 inch thick. Some brecciation w/silt and clay infill. Sandstone, from 510-512 ft, reddish brown (2.5YR4/4), slighty calcareous, fine grained, silty, moderately rounded and sorted. Crumbly, poor recovery. Sandstone and sulfate, white, brown, and bluish-gray, laminated (~0.05-0.2 inch) from about 511-511.3 ft.	top of A-1 depth based on drilling rate change End of run 6 actually at 527.1 ft
Core Run 7	530 540	Cut 15.8 ft; rec 14.8 (93.7%)	1.0' length in segments < 4" (RQD: 93.2)	Sandstone, fine to very fine, silty, slightly calcareous, halite cemented. Generally laminar (from 0.05 inch) to thin beds, especially 538.7-542 ft, less apparent above 538.7. Some ripples about 0.5 inch high, mostly subhorizontal to horizontal bedding, low angle planar bedding. Gypsum clasts (0.05 inch), fining upward, at 533 ft. Unit is more gypsiferous upward. Dark brown (7.5YR4/4) w/gray zones from 527.2-538.3; gray (10YR5/1) and dark reddish brown (5YR3/4) from 538.3-542.6 ft.	Core run 7 marked assuming recovery from base and loss of core at top.

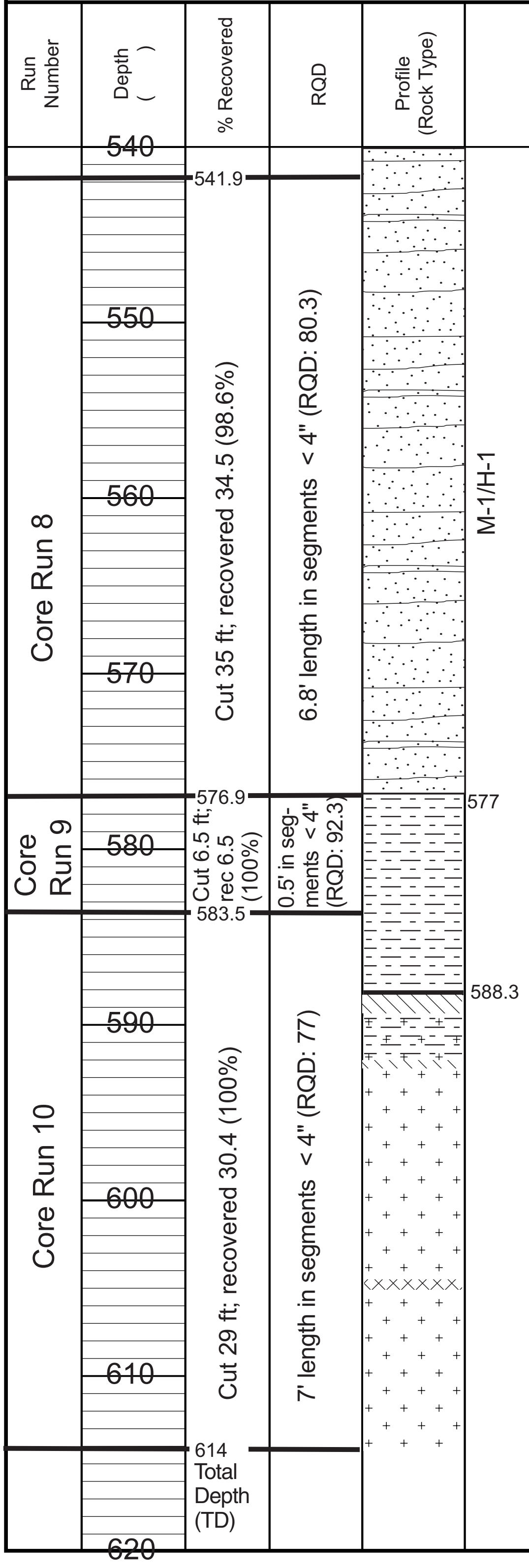
Hole ID: SNL-2

CORE LOG
(cont. sheet)

Sheet 7 of 7

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

Date: 5/2/03; 5/5-6/3/03



Description

542.6-545.3: dark reddish gray (5YR4/2)

545.3-586: gray (10YR5/1) to (5Y5/1)
547-550: 0.5 inch wide near-vertical fracture with orange fibrous halite filling

554: ~1 inch horizontal fracture filled with halite

542-577.7: Sandstone, very fine to fine, silty, with siltstone interbeds; halite cement is pervasive, with large poikilotopic crystals 1-2 inches; slightly calcareous. Laminae and thin beds, with low angle bedding is common; some probable ripples. Scattered intraclasts and small (0.05-0.1 inch) clasts(?) of sulfate; bioturbation likely, especially in lower part of this interval.

577-~587: Siltstone and fine sandstone, gray (10YR5/1), laminae, thin beds, low angle planar bedding; possible bioturbation; intraclasts @ 585.5; fracture 580.1-581.4, subvertical, no fill; near horizontal slickensides @ 580.1.
587-588.3: Siltstone, reddish brown (2.5YR4/4), laminar to thin bedding; sulfate clasts and cross-cutting erosion surface near base.

Base of Los Medaños Member and Rustler Fm

Top of Salado Formation

588.3-589.3: Anhydrite, white, thin laminae; siltstone. 589.3-590.7: Mudstone, w/displacive halite, polyhalite crystal linings and stringers. 590.7-592.1: Halite and mudstone. 592.1: Anhydrite and polyhalite, discontinuous. 592.1-594.4: Halite, with increasing clay, some polyhalite upward, thin clay at top. 594.4-596.6: Mudstone and halite, some probable displacive halite crystals w/polyhalite rims. 596.6-603: Halite, with blebs and stringers of reddish brown (2.5YR4/4) clay and subvertical to irregular polyhalite along and around halite; clay and polyhalite increase upward. 603-604.8: Halite, white, very coarse, possibly bedded. 604.8-605: Polyhalite, reddish orange, and halite. 605-607.4: Halite, white, very coarse, with ~2-5% clay, increasing upward, to thin (~ 0.5 inch) halitic brown claystone at top. possible podular texture. 607.4-614: Halite, white, very coarse, w/traces of polyhalite and sylvite (some dissolved). Bedded 2-8 inches thick, with some thin, discontinuous laminae of anhydrite and polyhalite.

Remarks

541.9 ft (542.9) end coring 5/2/03; begin coring 5/5/03

583.5 ft (584.5) end coring 5/5/03; begin coring 5/6/03

Drilling interval for core run 10 may have been 30 ft, with some core cut in previous runs (0.4 ft?) also recovered.

End coring @ 614 @ 8:22 a MDT, 5/6/03; circulate on bottom. Hole enlarging below Culebra and filling when hole re-entered. Decided to complete drillhole without deepening to Salado MB.

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Appendix D
Geophysical Logs

Geophysical Logging of SNL-2 was conducted by Geophysical Logging Services, 6250 Michele Lane, Prescott, AZ 86305, on May 7, 2003, and on May 14, 2003. The operator was Raymond Federwisch. Copies of the logs are maintained by Washington Regulatory and Environmental Services, Hydrology Division, for the WIPP project. A CD-ROM is being retained by the Hydrology Division that includes:

1) Eectronic copies of the logs produced by Geophysical Logging Services using WellCAD vs 3.2,
2) WellCAD Reader to open the electronic logs, and
3) Electronic data files in both .txt and .las formats.

On May 7, 2003, the following geophysical logs were obtained:

- Caliper
- Natural gamma
- Neutron
- Density
- Formation resistivity (including induction log)
- Fluid resistivity
- Fluid (or drillhole air) temperature

The drillhole was open to about 517 ft bgl at the time of logging. A conductor casing had been emplaced to a depth of 30 ft bgl. The fluid level at the time of logging was about 363 ft bgl.

On May 14, 2003, the following geophysical logs were obtained after the drillhole was reamed using a 12.25-inch-diameter bit to a depth of about 489 ft bgl:

- Caliper (0-488.3 ft)
- Optical televiewer (62.4-363.5 ft)

The drillhole was logged to a depth of 488.3 ft with a caliper log before casing was placed. The televiewer log obtained data to 323 ft bgl but was unusable below that depth, apparently due to the presence of foam. The optical televiewer log includes drillhole deviation data usable for interpreting the orientation of fractures or other features observable in the televiewer log.

[Electronic files for the final caliper and optical televiewer data are maintained for the WIPP project by the Environmental Monitoring and Hydrology Section, Washington Regulatory and Environmental Services].

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Appendix E

Permitting and Completion Information

A case file for SNL-2 (C-2948) containing official documents is maintained by the land management department 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-2948.

Information on management of well-drilling wastes for SNL-2 is included at the end of this appendix. Original files are maintained by Washington Regulatory and Environmental Services.

Dennis W. Powers, Ph. D.
Consulting Geologist

May 6, 2003

Ron Richardson
Field Lead
WRES

Rick Beauheim
Hydrology Lead
Sandia National Laboratories

Re: Decision to stop drilling SNL-2 in the upper Salado Formation

During a telephone conference from the site of SNL-2 this afternoon, I recommended to you that SNL-2 should not be deepened beyond its present depth of about 614 ft below ground level (bgl). I believe the drillhole has already yielded significant information about the Rustler Formation and about the limits of upper Salado dissolution. Although additional information about the thickness of upper Salado units would be helpful, I believe that this information is not necessary and does not justify the additional difficulties to obtain the information. Other existing drillholes in the vicinity of SNL-2 provide stratigraphic data indicating the lack of significant dissolution of the upper Salado at this location; the core data are consistent with that information.

Because some of the less indurated units of the Rustler are beginning to slough into the hole as drilling activities continue, there is a significant chance that the hole could become useless if we try to deepen it. Drilling with bentonite might stabilize the drillhole, but this would significantly degrade the hydraulic character of the Culebra. Very extensive, and possibly inappropriate, hydraulic development would be necessary to try to overcome these effects. The principal purpose of the drillhole is to obtain hydraulic information about the Culebra in this area, and we should not risk the drillhole by deepening.

The next recommended series of activities now starts by attempting to obtain geophysical logs of the drillhole through the Culebra and overlying units. If this is successful, the drillhole can be reamed to a final diameter, the screening interval for the Culebra can be selected, the drillhole below the Culebra can be plugged, and the well can be completed and developed. If the drillhole through the Culebra is not accessible for logging, a likely course of action will be to re-enter the drillhole and attempt to re-open the hole through the Culebra, using a polymer in the drilling fluid.

I believe this letter summarizes the discussions we had this afternoon and presents the hydrological and geological justification for not deepening SNL-2 further to obtain additional upper Salado stratigraphic data.

Sincerely,

Dennis W. Powers

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

Dennis W. Powers, Ph. D.
Consulting Geologist

May 8, 2003

Ron Richardson
Field Lead
WRES

Rick Beauheim
Hydrology Lead
Sandia National Laboratories

Re: Screen Interval for Culebra Dolomite Member in SNL-2

Our discussions regarding the Culebra Dolomite Member in SNL-2 indicate that the best interval to screen is from 480-453 ft below the top of the conductor casing.

These are the factors we considered in this decision:

- The screened or slotted section of a single casing joint is 27 ft long.
- The Culebra interval, as indicated by the natural gamma geophysical log, is from 456-481 ft below the top of the conductor casing.
- The core, although incomplete below the Culebra, indicated that the laminated claystone immediately underlying the Culebra behaves plastically, and the screened interval should be kept above this zone to prevent it from squeezing into the slots.
- The core and geophysical logs above the Culebra indicate the anhydrite/gypsum units are intact, separating the Culebra from the overlying Tamarisk Member mudstone (M-3) by about 16 ft.
- There is no indication of halite in the mudstone unit (M-2) below the Culebra and above the anhydrite (A-1)about 10 ft below the Culebra at this location.

By placing the bottom of the screened interval 480 ft below the top of the conductor, the mudstone below the Culebra should be isolated from squeezing into the screens, and the top of the screened interval at 453 ft below the top of the conductor should be isolated from the Tamarisk Member mudstone.

To provide adequate space below the screened interval for pumping, a minimum 10 ft long blank casing should be added below the 30 ft long screened pipe. The lower part of the hole, as it currently exists, should be cemented up into the anhydrite unit (A-1) from 490-500 ft below the top of the conductor casing to minimize circulation into the lower halite-cemented zones (M-1/H-1) at this location.

I believe this letter summarizes the discussions we had this afternoon and presents the hydrological and geological justification for setting the screened interval and preparing SNL-2 for completion.

Sincerely,

Dennis W. Powers

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

Dennis W. Powers, Ph. D.
Consulting Geologist

May 13, 2003

Rey Carrasco
Geotechnical Engineering
Washington TRU Solutions
Carlsbad, NM 88220

Storage and Retention of Cores and Rock Samples from SNL-2

Background

Cores and cutting samples have been collected from drillhole SNL-2 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 Ron Richardson (WRES). SNL-2 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-2 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-2 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-2 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.

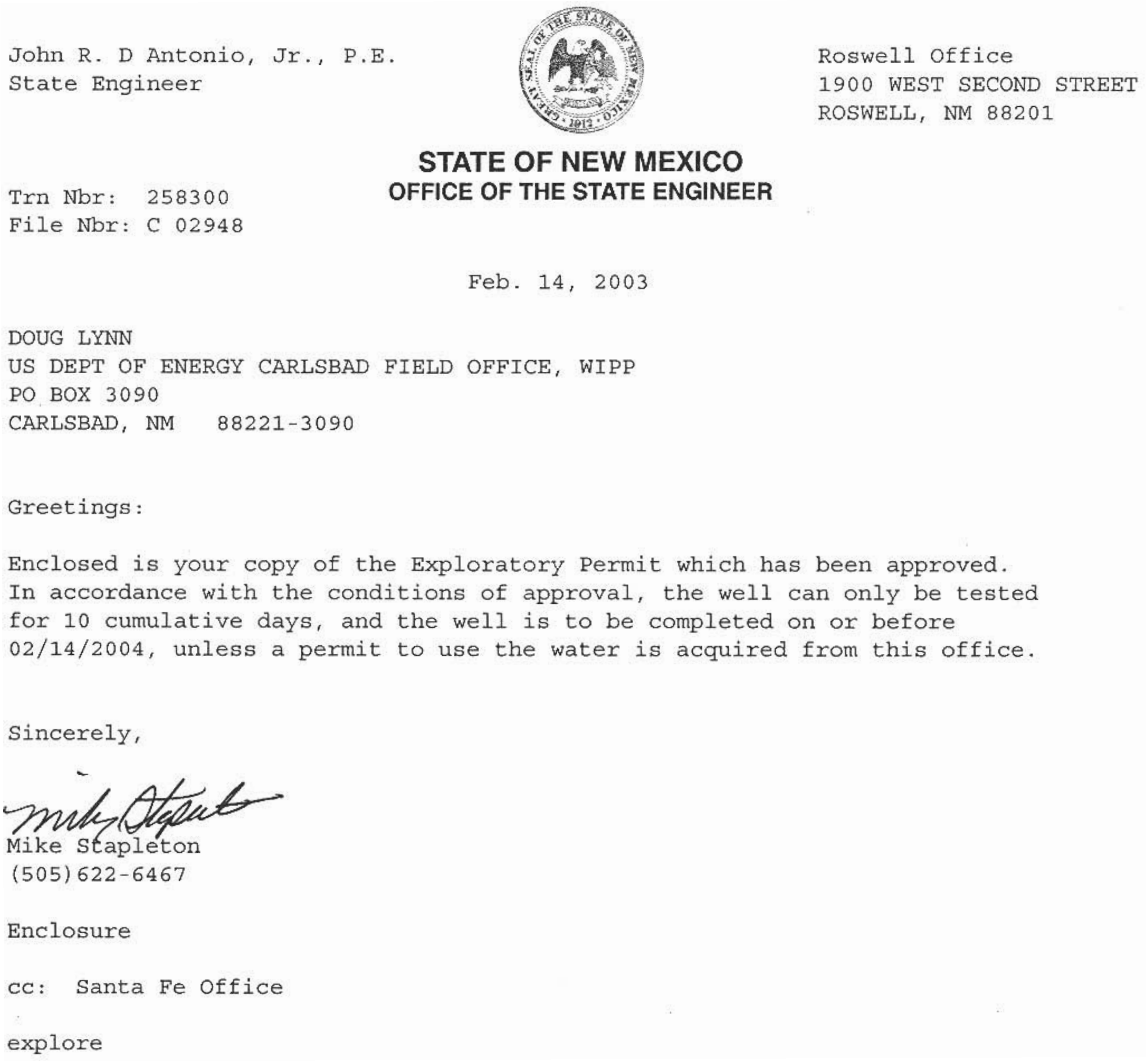
Supplemental Information

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-2.

Dennis W. Powers

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

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



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

Roswell Office
1900 WEST SECOND STREET
ROSWELL, NM 88201

1912

STATE OF NEW MEXICO
OFFICE OF THE STATE ENGINEER

Trn Nbr: 258300
File Nbr: C 02948

Feb. 14, 2003

DOUG LYNN
US 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 completed on or before 02/14/2004, unless a permit to use the water is acquired from this office.

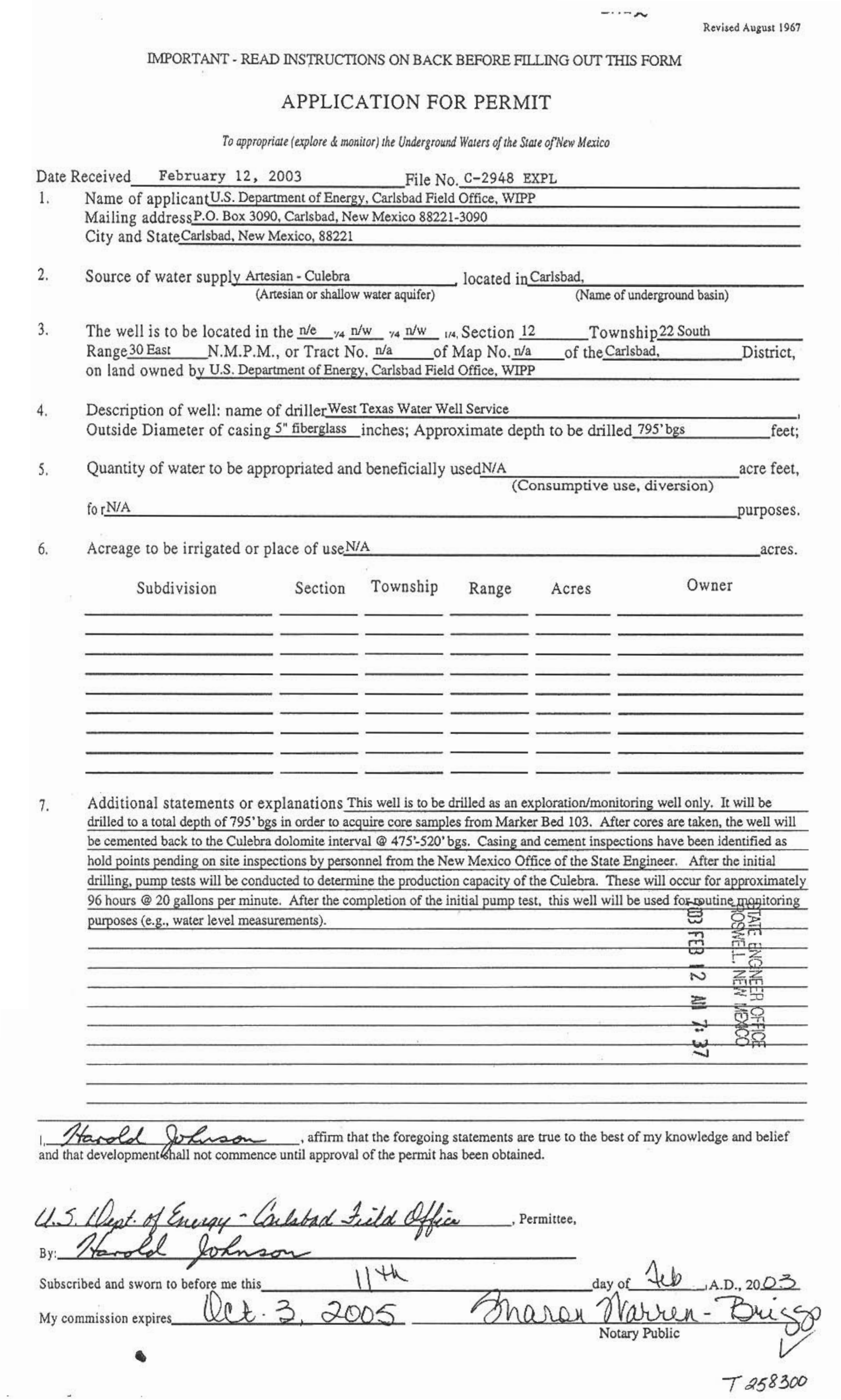
Sincerely,

Mike Stapleton
(505)622-6467

Enclosure

cc: Santa Fe Office

explore



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 February 12, 2003 File No. C-2948 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 n/e ¼ n/w ¼ n/w ¼, Section 12 Township 22 South
Range 30 East N.M.P.M., or Tract No. n/a of Map No. n/a of the Carlsbad, District,
on land owned by U.S. Department of Energy, Carlsbad Field Office, WIPP

4. Description of well: name of driller West Texas Water Well Service,
Outside Diameter of casing 5" fiberglass inches; Approximate depth to be drilled 795' bgs feet;

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

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

Subdivision	Section	Township	Range	Acres	Owner

7. Additional statements or explanations This well is to be drilled as an exploration/monitoring well only. It will be drilled to a total depth of 795' bgs in order to acquire core samples from Marker Bed 103. After cores are taken, the well will be cemented back to the Culebra dolomite interval @ 475'-520' bgs. Casing and cement inspections have been identified as hold points pending on site inspections by personnel from the New Mexico Office of the State Engineer. After the initial drilling, pump tests will be conducted to determine the production capacity of the Culebra. These will occur for approximately 96 hours @ 20 gallons per minute. After the completion of the initial pump test, this well will be used for routine monitoring purposes (e.g., water level measurements).

2003 FEB 12 AM 7:37
STATE ENGINEER OFFICE
ROSWELL, NEW MEXICO

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

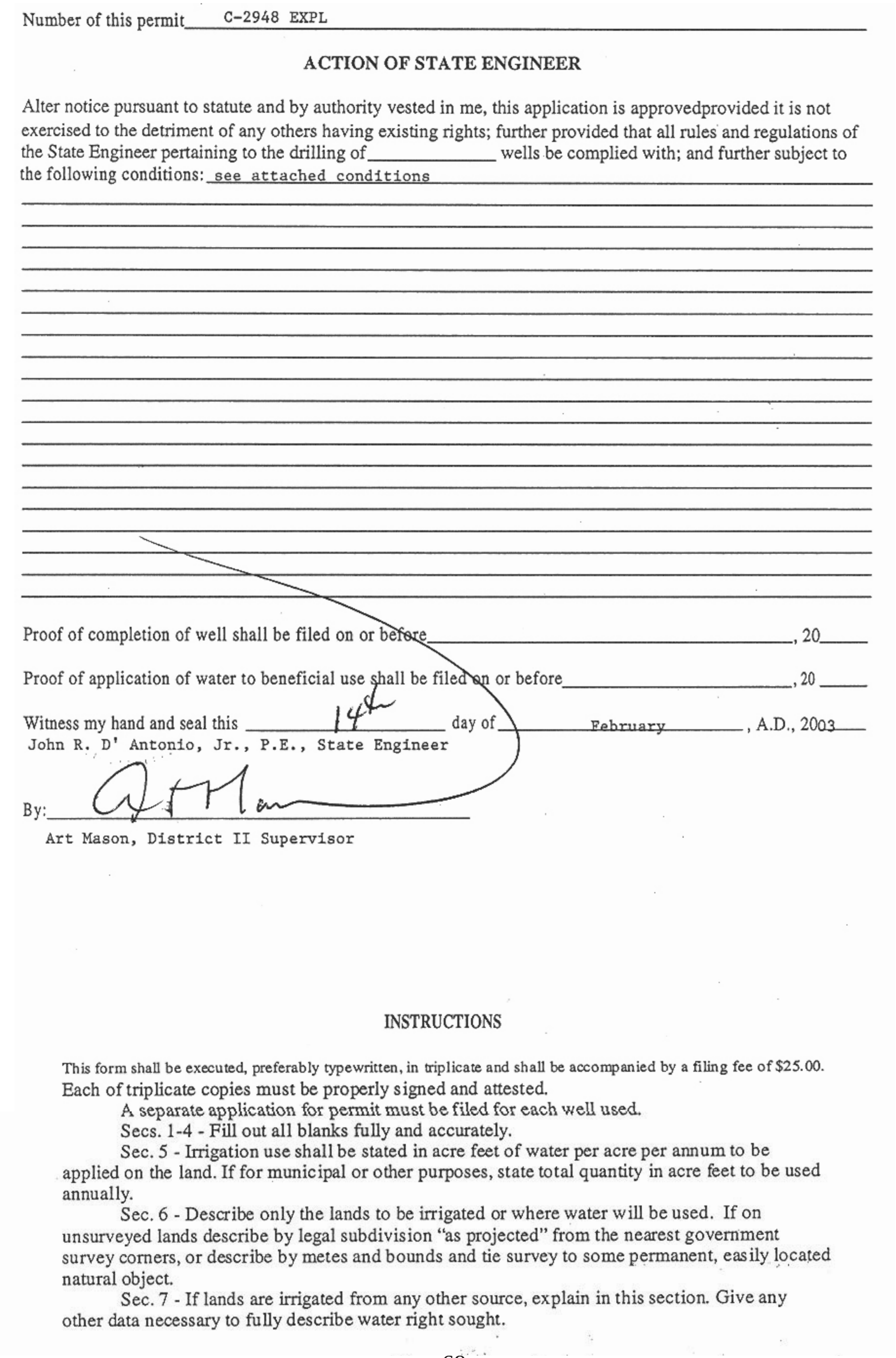
U.S. Dept. of Energy - Carlsbad Field Office, Permittee,

By: Harold Johnson

Subscribed and sworn to before me this 11th day of Feb, A.D., 2003

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

T 258300



Number of this permit C-2948 EXPL

ACTION OF STATE ENGINEER

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

Proof of completion of well shall be filed on or before ______, 20____

Proof of application of water to beneficial use shall be filed on or before ______, 20____

Witness my hand and seal this 14th day of February, A.D., 2003

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.

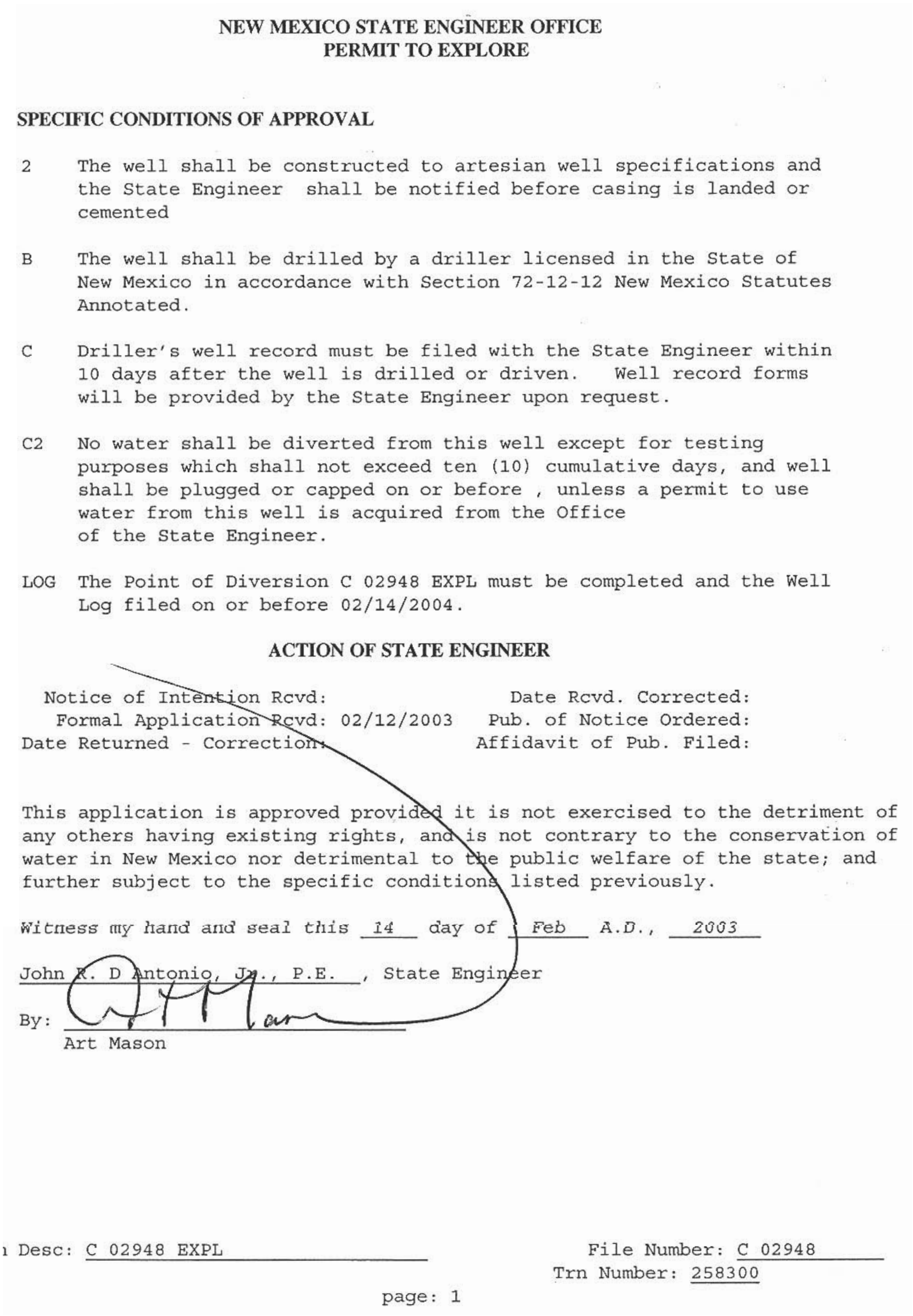
A separate application for permit must be filed for each well used.

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.



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 , unless a permit to use water from this well is acquired from the Office of the State Engineer.

LOG The Point of Diversion C 02948 EXPL must be completed and the Well Log filed on or before 02/14/2004.

ACTION OF STATE ENGINEER

Notice of Intention Rcvd:		Date Rcvd. Corrected:	
Formal Application Rcvd:	02/12/2003	Pub. of Notice Ordered:	
Date Returned - Correction:		Affidavit of Pub. Filed:	

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

Witness my hand and seal this 14 *day of* Feb *A.D.,* 2003

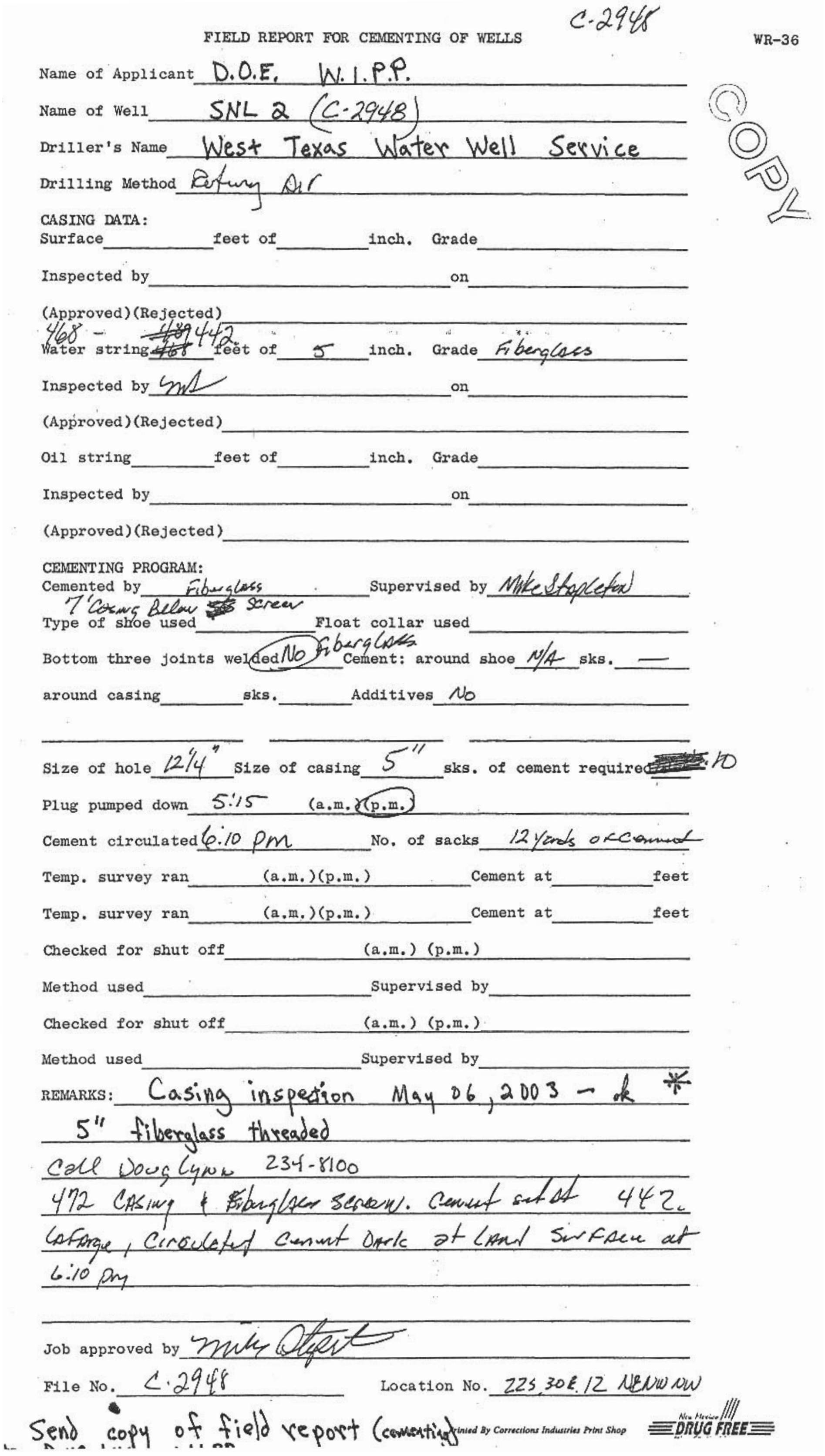
John R. D Antonio, Jr., P.E. , State Engineer

By:
Art Mason

Desc: C 02948 EXPL

File Number: C 02948
Trn Number: 258300

page: 1



C-2948

FIELD REPORT FOR CEMENTING OF WELLS

WR-36

COPY

Name of Applicant D.O.E. W.I.P.P.

Name of Well SNL 2 (C-2948)

Driller's Name West Texas Water Well Service

Drilling Method Rotary Air

CASING DATA:

Surface ___ feet of ___ inch. Grade ___

Inspected by ___ on ___

(Approved)(Rejected) ___

Water string 468 – ~~480~~ 442 ~~468~~ feet of 5 inch. Grade Fiberglass

Inspected by ___ on ___

(Approved)(Rejected) ___

Oil string ___ feet of ___ inch. Grade ___

Inspected by ___ on ___

(Approved)(Rejected) ___

CEMENTING PROGRAM:

Cemented by Fiberglass Supervised by Mike Stapleton

Type of shoe used 7' Casing Below Screen Float collar used ___

Bottom three joints welded [✓ No] Fiberglass Cement: around shoe N/A sks. —

around casing ___ sks. ___ Additives No

Size of hole 12¼" Size of casing 5" sks. of cement required 10

Plug pumped down 5:15 (a.m.) [✓ (p.m.)]

Cement circulated 6:10 pm No. of sacks 12 yards of Cement

Temp. survey ran ___ (a.m.)(p.m.) ___ Cement at ___ feet

Temp. survey ran ___ (a.m.)(p.m.) ___ Cement at ___ feet

Checked for shut off ___ (a.m.) (p.m.)

Method used ___ Supervised by ___

Checked for shut off ___ (a.m.) (p.m.)

Method used ___ Supervised by ___

REMARKS: Casing inspection May 06, 2003 – ok *
5" fiberglass threaded
Call Doug Lynn 234-8100
472 Casing & Fiberglass Screen. Cement set at 442.
Lafarge, Circulated Cement Dark at Land Surface at
6:10 pm

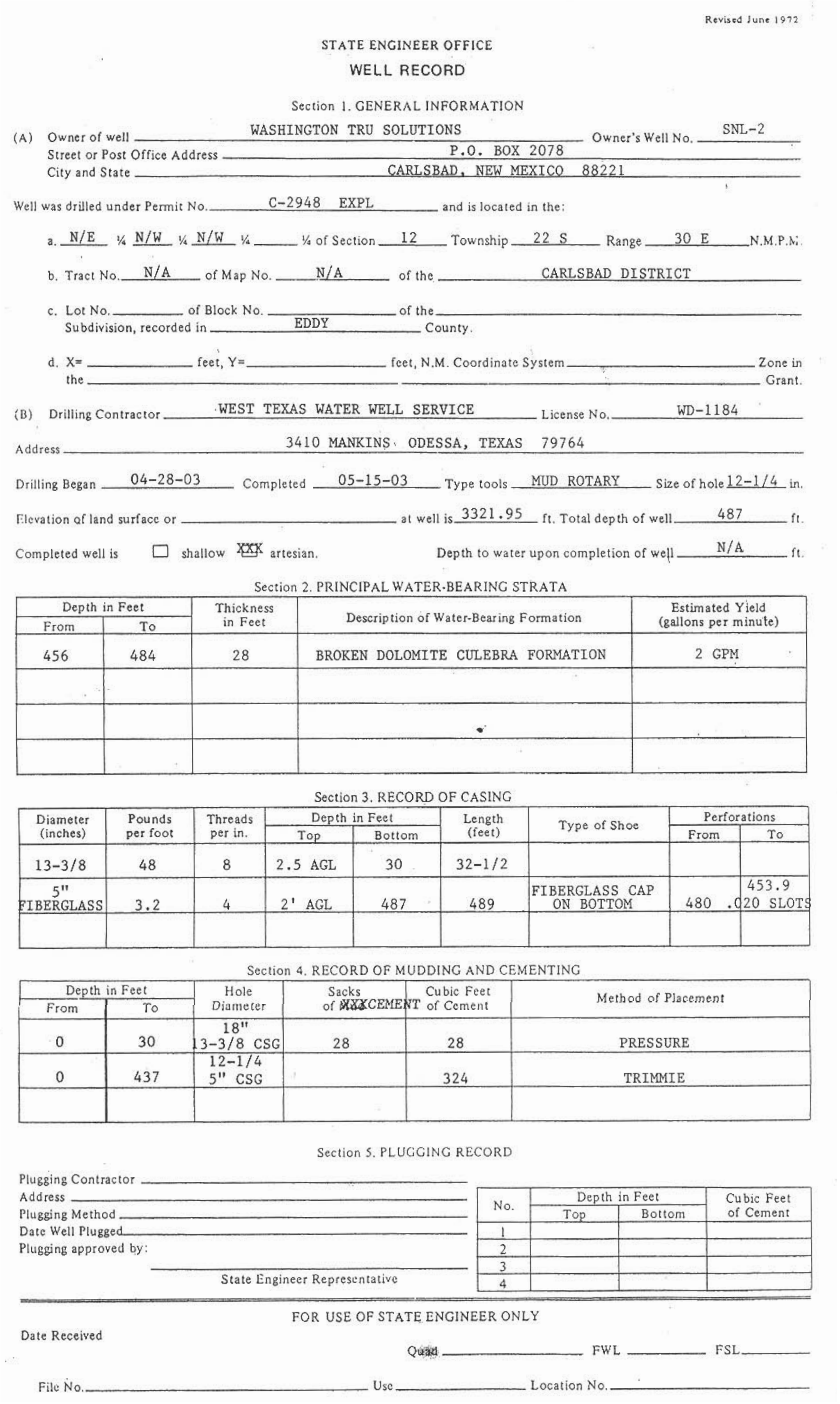
Job approved by Mike

File No. C-2948 Location No. 22S.30E.12 NENW NW

Send copy of field report (cementing)

Printed By Corrections Industries Print Shop

New Mexico DRUG FREE



Revised June 1972

STATE ENGINEER OFFICE

WELL RECORD

Section 1. GENERAL INFORMATION

(A) Owner of well WASHINGTON TRU SOLUTIONS Owner's Well No. SNL-2
Street or Post Office Address P.O. BOX 2078
City and State CARLSBAD, NEW MEXICO 88221

Well was drilled under Permit No. C-2948 EXPL and is located in the:

a. N/E ¼ N/W ¼ N/W ¼ ____ ¼ of Section 12 Township 22 S Range 30 E N.M.P.M.

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

c. Lot No. ____ of Block No. ____ of the ____
Subdivision, recorded in EDDY County.

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

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

Address 3410 MANKINS ODESSA, TEXAS 79764

Drilling Began 04-28-03 Completed 05-15-03 Type tools MUD ROTARY Size of hole 12-1/4 in.

Elevation of land surface or ____ at well is 3321.95 ft. Total depth of well 487 ft.

Completed well is ☐ shallow ☒ artesian. Depth to water upon completion of well N/A 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			
456	484	28	BROKEN DOLOMITE CULEBRA FORMATION	2 GPM

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	32-1/2			
5" FIBERGLASS	3.2	4	2' AGL	487	489	FIBERGLASS CAP ON BOTTOM	480	453.9 .020 SLOTS

Section 4. RECORD OF MUDDING AND CEMENTING

Depth in Feet		Hole Diameter	Sacks of ~~Mud~~CEMENT	Cubic Feet of Cement	Method of Placement
From	To				
0	30	18" 13-3/8 CSG	28	28	PRESSURE
0	437	12-1/4 5" CSG		324	TRIMMIE

Section 5. PLUGGING RECORD

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

____
State Engineer Representative

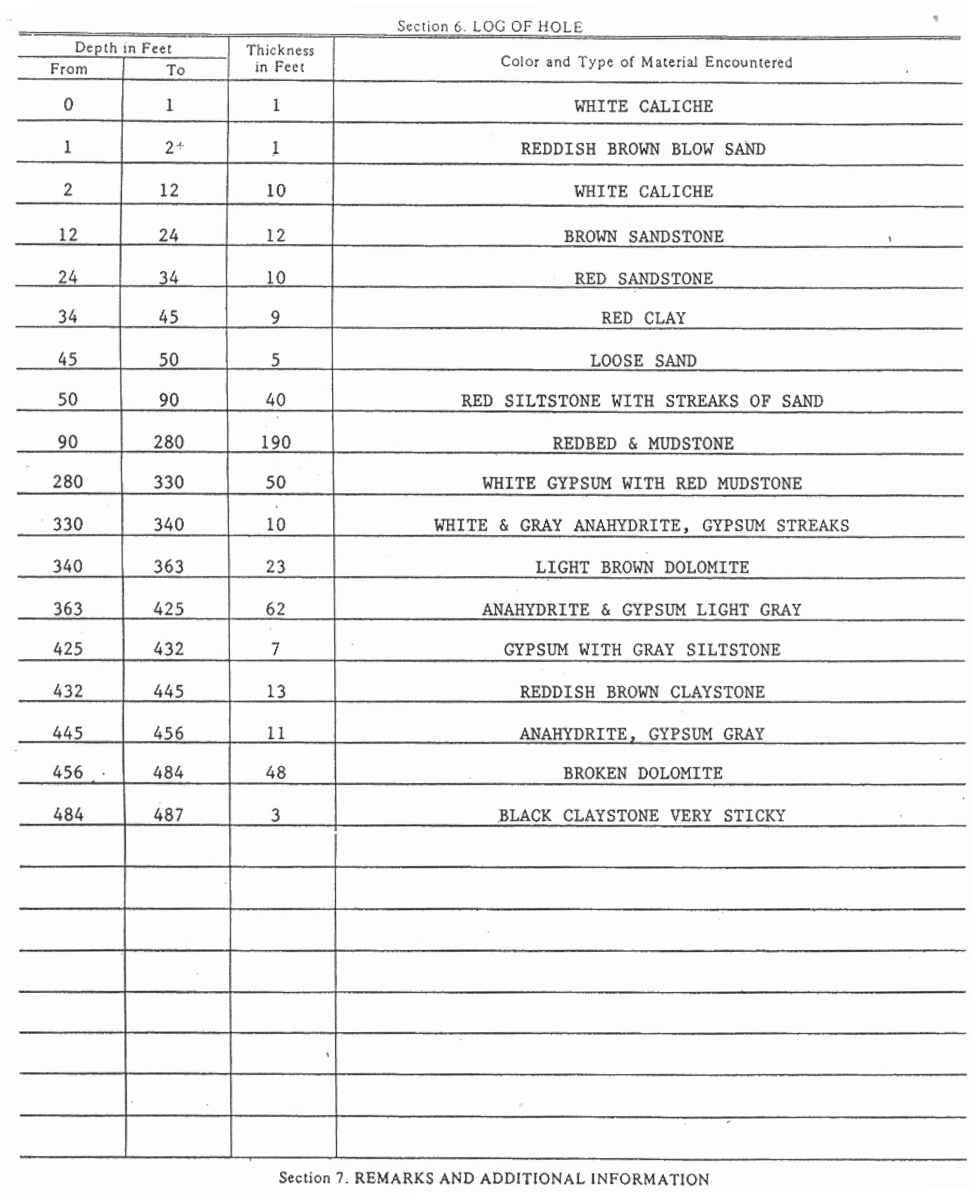
No.	Depth in Feet		Cubic Feet of Cement
	Top	Bottom	
1			
2			
3			
4			

FOR USE OF STATE ENGINEER ONLY

Date Received

Quad ____ FWL ____ FSL ____

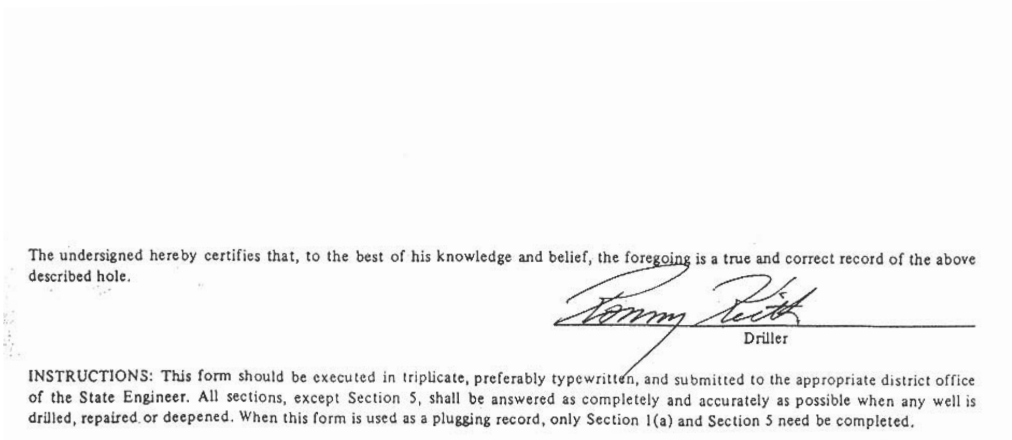
File No. ____ Use ____ Location No. ____



Section 6. LOG OF HOLE

Depth in Feet		Thickness in Feet	Color and Type of Material Encountered
From	To		
0	1	1	WHITE CALICHE
1	2	1	REDDISH BROWN BLOW SAND
2	12	10	WHITE CALICHE
12	24	12	BROWN SANDSTONE
24	34	10	RED SANDSTONE
34	45	9	RED CLAY
45	50	5	LOOSE SAND
50	90	40	RED SILTSTONE WITH STREAKS OF SAND
90	280	190	REDBED & MUDSTONE
280	330	50	WHITE GYPSUM WITH RED MUDSTONE
330	340	10	WHITE & GRAY ANAHYDRITE, GYPSUM STREAKS
340	363	23	LIGHT BROWN DOLOMITE
363	425	62	ANAHYDRITE & GYPSUM LIGHT GRAY
425	432	7	GYPSUM WITH GRAY SILTSTONE
432	445	13	REDDISH BROWN CLAYSTONE
445	456	11	ANAHYDRITE, GYPSUM GRAY
456	484	48	BROKEN DOLOMITE
484	487	3	BLACK CLAYSTONE VERY STICKY

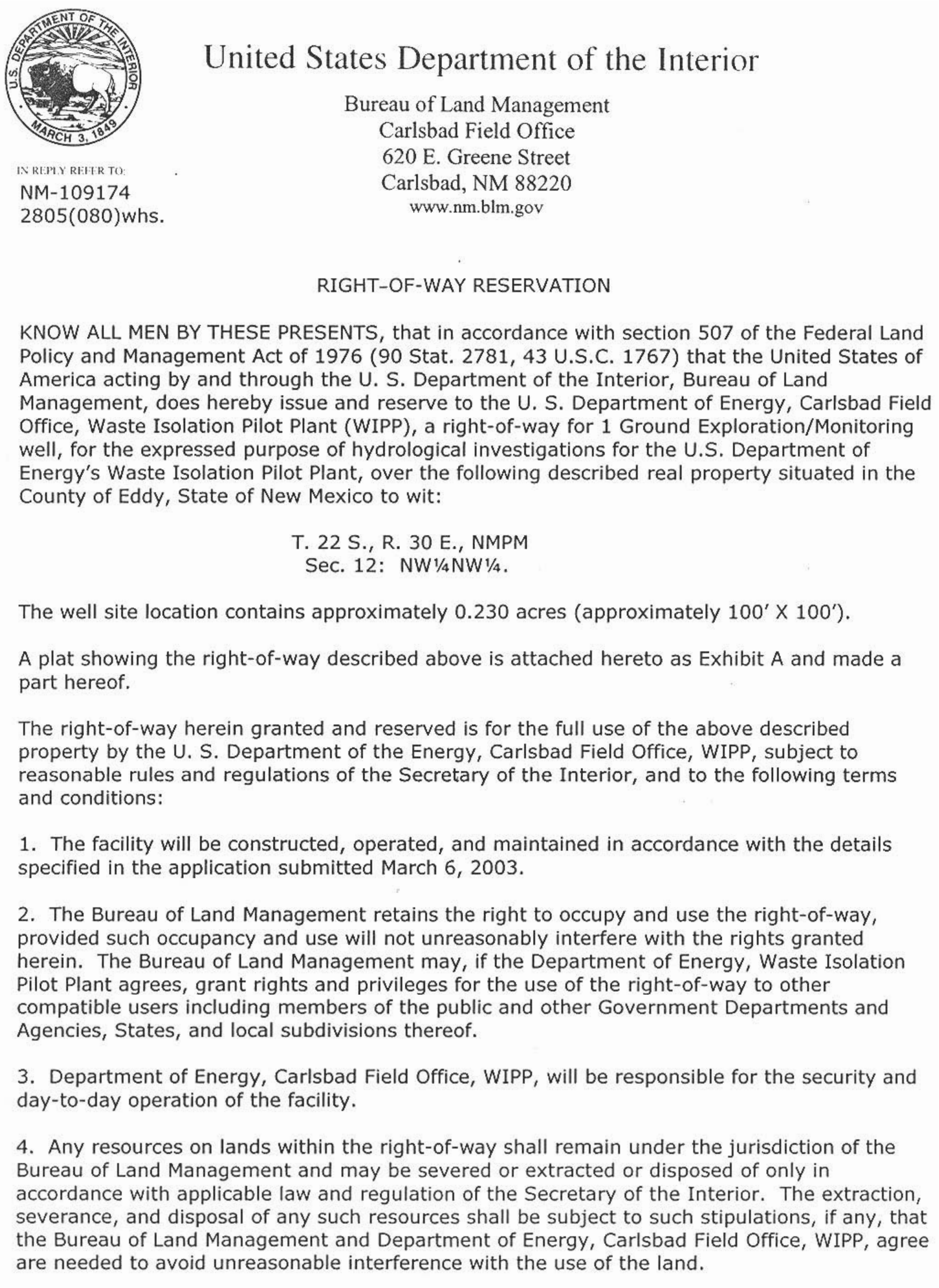
Section 7. REMARKS AND ADDITIONAL INFORMATION



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

Tommy Keith
Driller

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



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-109174
2805(080)whs.

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 1 Ground Exploration/Monitoring well, for the expressed purpose of hydrological investigations for the U.S. Department of Energy's Waste Isolation Pilot Plant, over the following described real property situated in the County of Eddy, State of New Mexico to wit:

T. 22 S., R. 30 E., NMPM
Sec. 12: NW¼NW¼.

The well site location contains approximately 0.230 acres (approximately 100' X 100').

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 the Energy, Carlsbad Field Office, WIPP, subject to reasonable rules and regulations of the Secretary of the Interior, and to the following terms and conditions:

1. The facility will be constructed, operated, and maintained in accordance with the details specified in the application submitted 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, Waste Isolation Pilot Plant agrees, 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. Attached are stipulations for reseeding. Exhibit A.

D. The well shall be properly plugged (See the attached Casing Program Plugging and Abandonment Requirements). Exhibit A-1.

E. Precautions will be taken for all arc and/or gas welding operations. Exhibit A-2.

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

Dated this 15th day of April, 2003.

Leslie A. Theiss

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

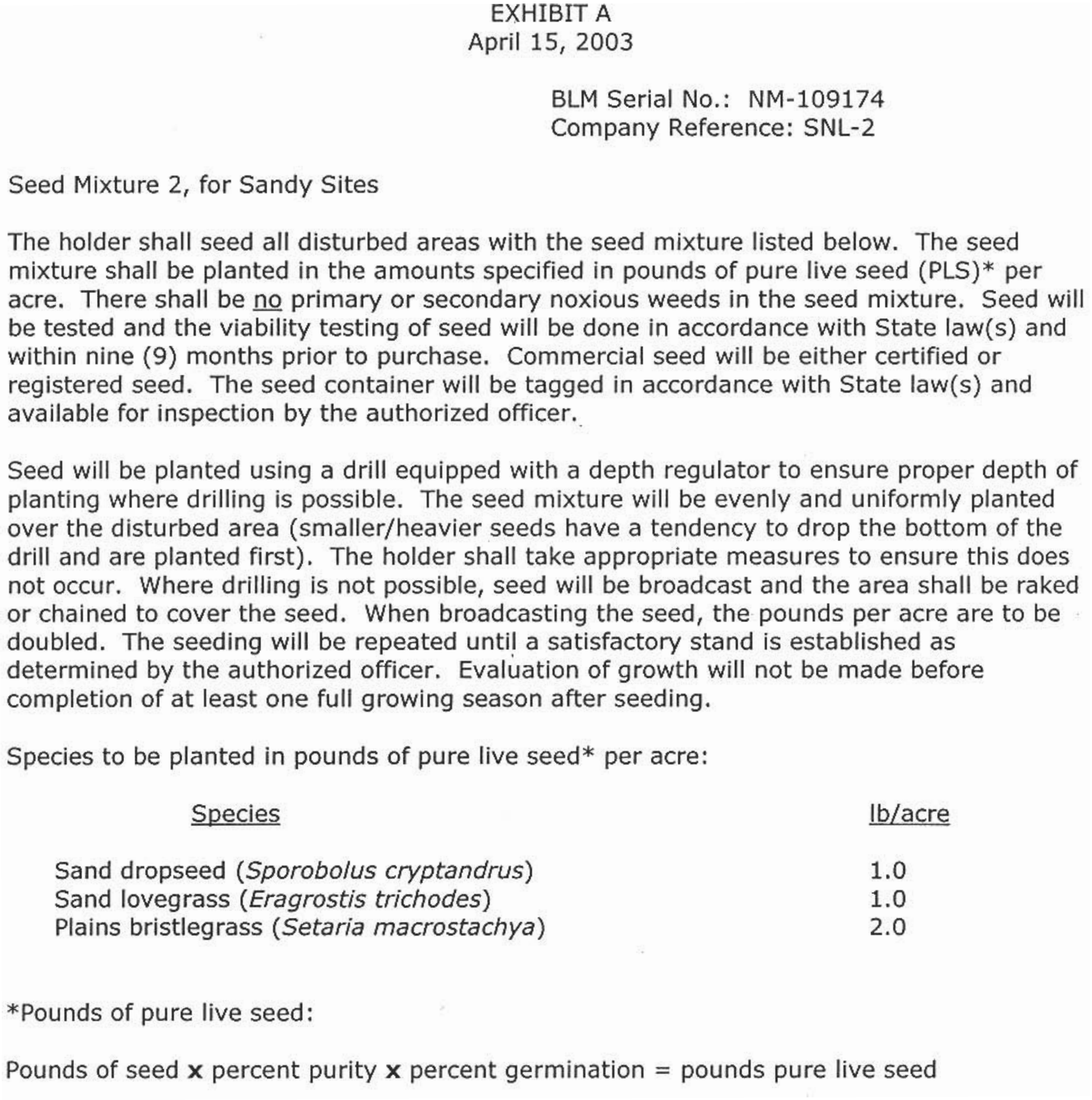


EXHIBIT A
April 15, 2003

BLM Serial No.: NM-109174
Company Reference: SNL-2

Seed Mixture 2, for Sandy 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.

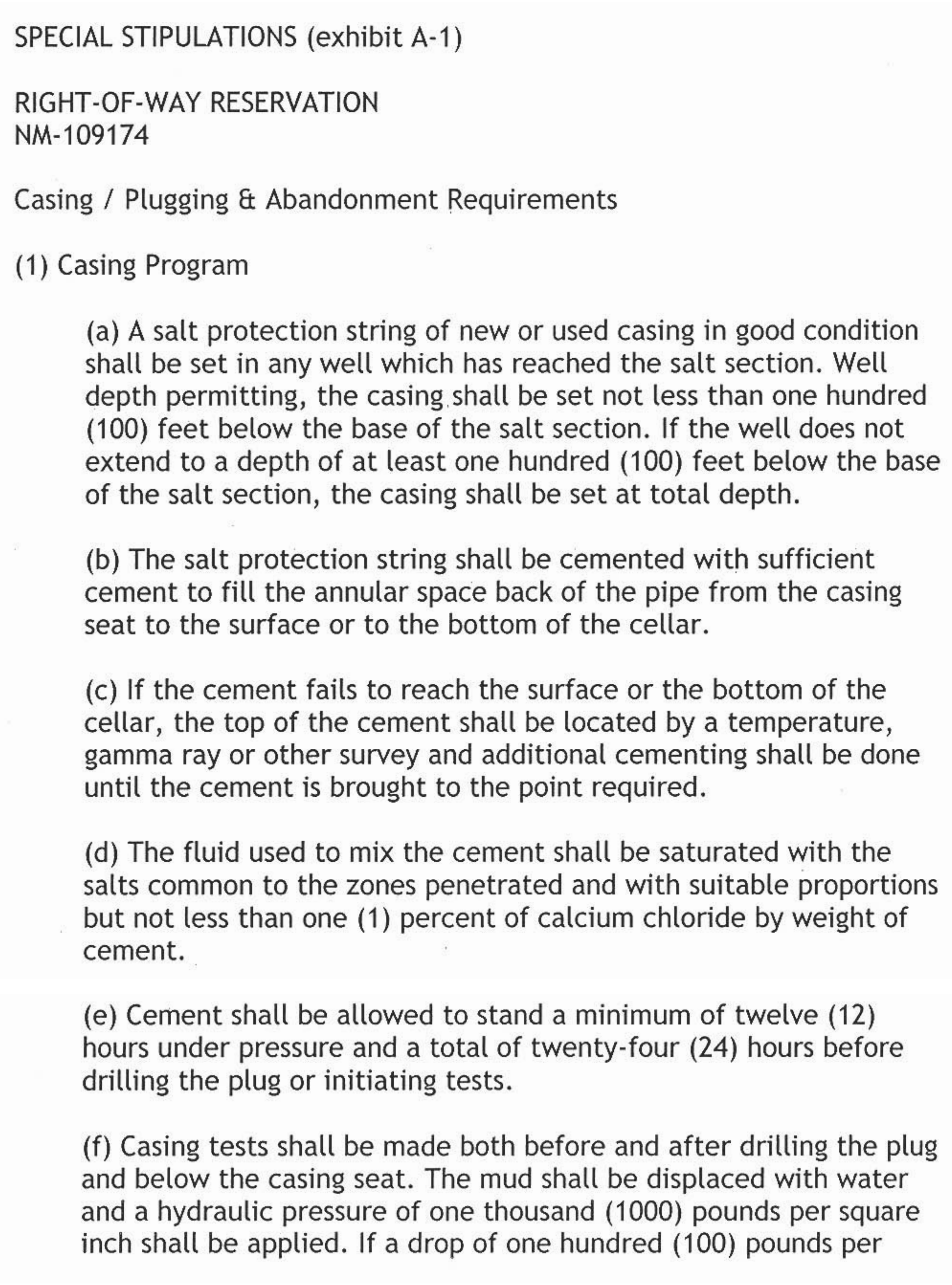
Seed will be planted using a drill equipped with a depth regulator to ensure proper depth of planting where drilling is possible. The seed mixture will be evenly and uniformly planted over the disturbed area (smaller/heavier seeds have a tendency to drop the bottom of the drill and are planted first). 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
Sand dropseed (*Sporobolus cryptandrus*)	1.0
Sand lovegrass (*Eragrostis trichodes*)	1.0
Plains bristlegrass (*Setaria macrostachya*)	2.0

*Pounds of pure live seed:

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



SPECIAL STIPULATIONS (exhibit A-1)

RIGHT-OF-WAY RESERVATION
NM-109174

Casing / Plugging & Abandonment Requirements

(1) Casing Program

(a) A salt protection string of new or used casing in good condition shall be set in any well which has reached the salt section. Well depth permitting, the casing shall be set not less than one hundred (100) feet below the base of the salt section. If the well does not extend to a depth of at least one hundred (100) feet below the base of the salt section, the casing shall be set at total depth.

(b) The salt protection string shall be cemented with sufficient cement to fill the annular space back of the pipe from the casing seat to the surface or to the bottom of the cellar.

(c) If the cement fails to reach the surface or the bottom of the cellar, the top of the cement shall be located by a temperature, gamma ray or other survey and additional cementing shall be done until the cement is brought to the point required.

(d) The fluid used to mix the cement shall be saturated with the salts common to the zones penetrated and with suitable proportions but not less than one (1) percent of calcium chloride by weight of cement.

(e) Cement shall be allowed to stand a minimum of twelve (12) hours under pressure and a total of twenty-four (24) hours before drilling the plug or initiating tests.

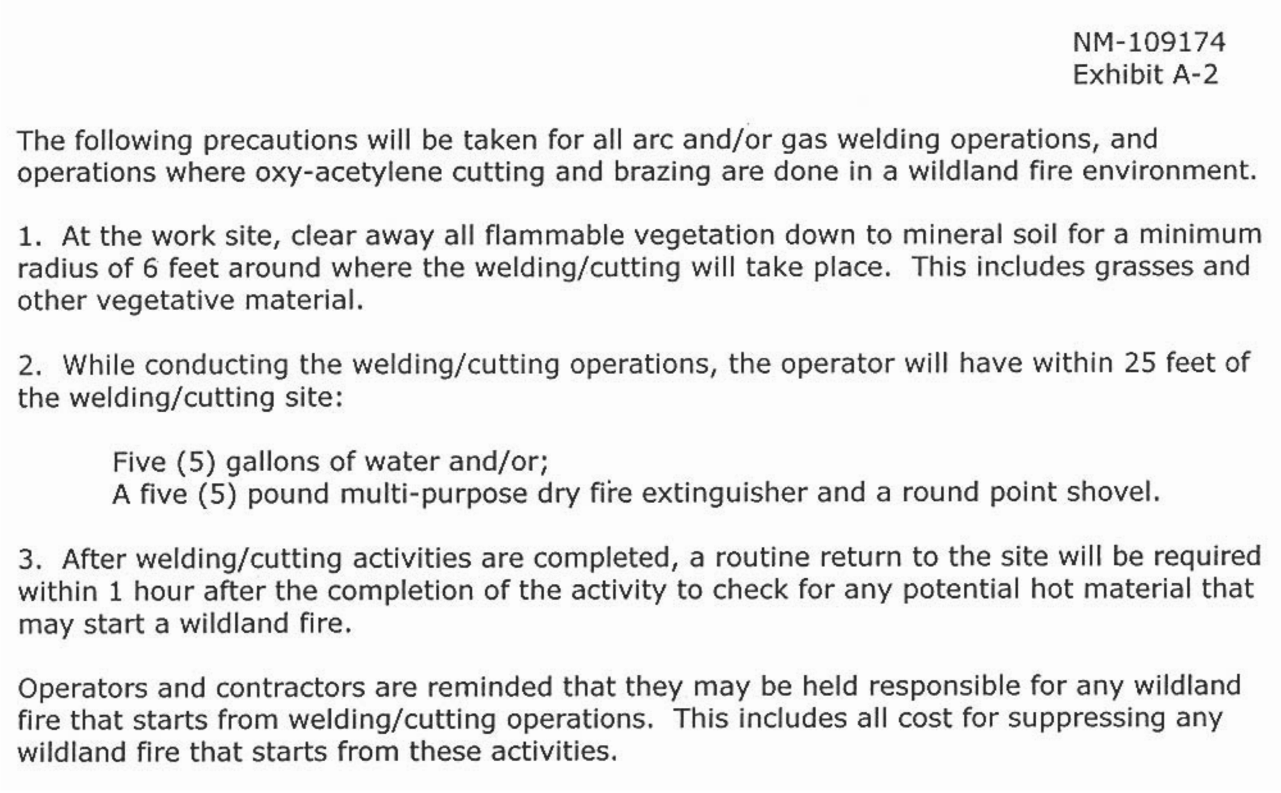
(f) Casing tests shall be made both before and after drilling the plug and below the casing seat. The mud shall be displaced with water and a hydraulic pressure of one thousand (1000) pounds per square inch shall be applied. If a drop of one hundred (100) pounds per square inch should occur within thirty (30) minutes, corrective measures shall be applied.

(g) The Bureau of Land Management may require the use of centralizers on the salt protection string when in their judgement the use of such centralizers would offer further protection to the salt section.

(2) Plugging and Abandonment

(a) The wells shall be plugged in a manner and in accordance with rules established by the Bureau of Land Management that will provide a solid cement plug from total depth to the surface.

(b) The fluid used to mix the cement shall be saturated with the salts common to the salt section penetrated and with suitable proportions but not more than three (3) percent of calcium chloride by weight of cement being considered the desired mixture whenever possible.



NM-109174
Exhibit A-2

The following precautions will be taken for all arc and/or gas welding operations, and operations where oxy-acetylene cutting and brazing are done in a wildland fire environment.

1. At the work site, clear away all flammable vegetation down to mineral soil for a minimum radius of 6 feet around where the welding/cutting will take place. This includes grasses and other vegetative material.

2. While conducting the welding/cutting operations, the operator will have within 25 feet of the welding/cutting site:

> Five (5) gallons of water and/or;
> A five (5) pound multi-purpose dry fire extinguisher and a round point shovel.

3. After welding/cutting activities are completed, a routine return to the site will be required within 1 hour after the completion of the activity to check for any potential hot material that may start a wildland fire.

Operators and contractors are reminded that they may be held responsible for any wildland fire that starts from welding/cutting operations. This includes all cost for suppressing any wildland fire that starts from these activities.

Page 1 of 2

NM-109174

Survey for the SNL-2/WTS-1 Water Monitoring Well

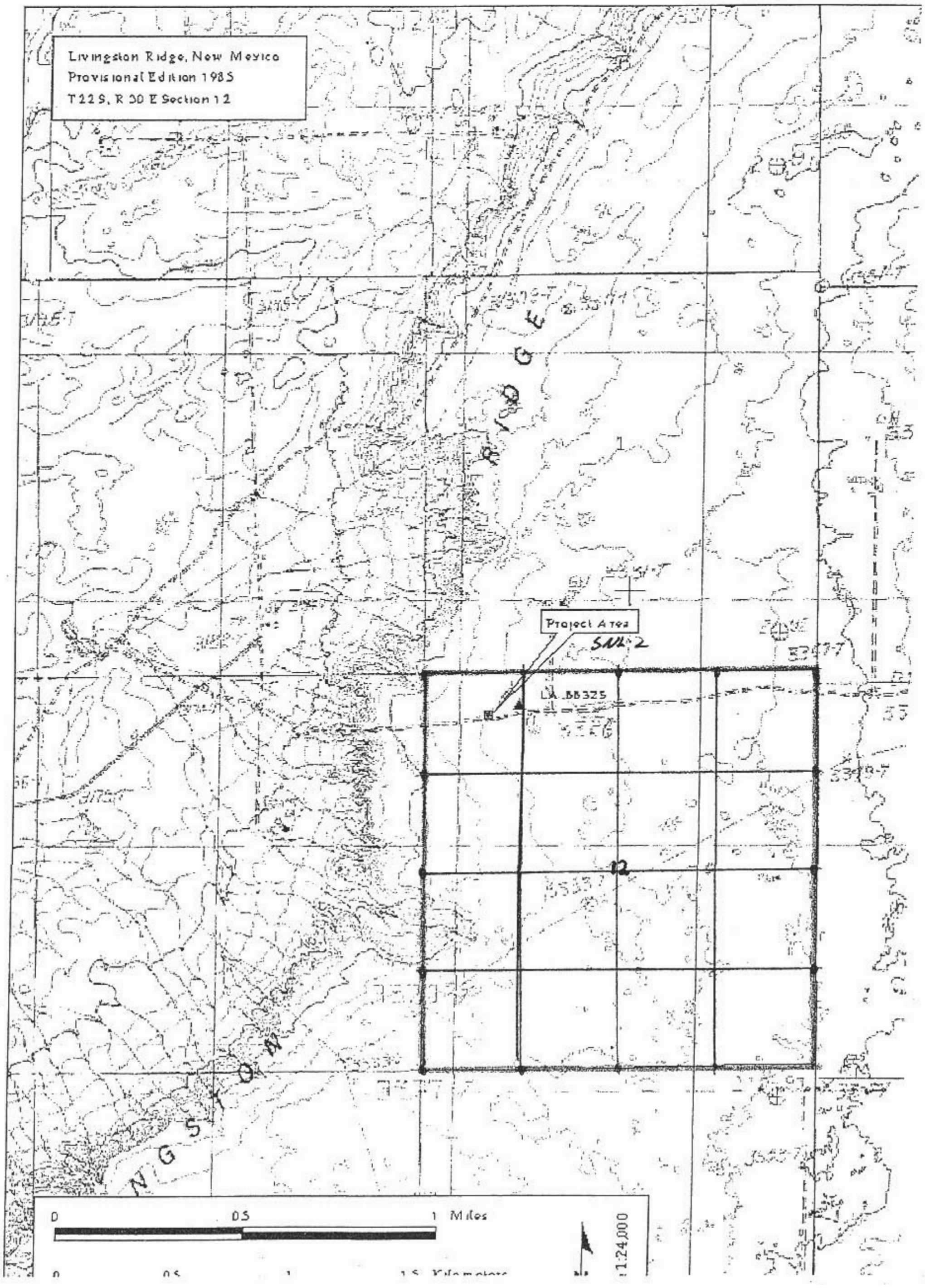
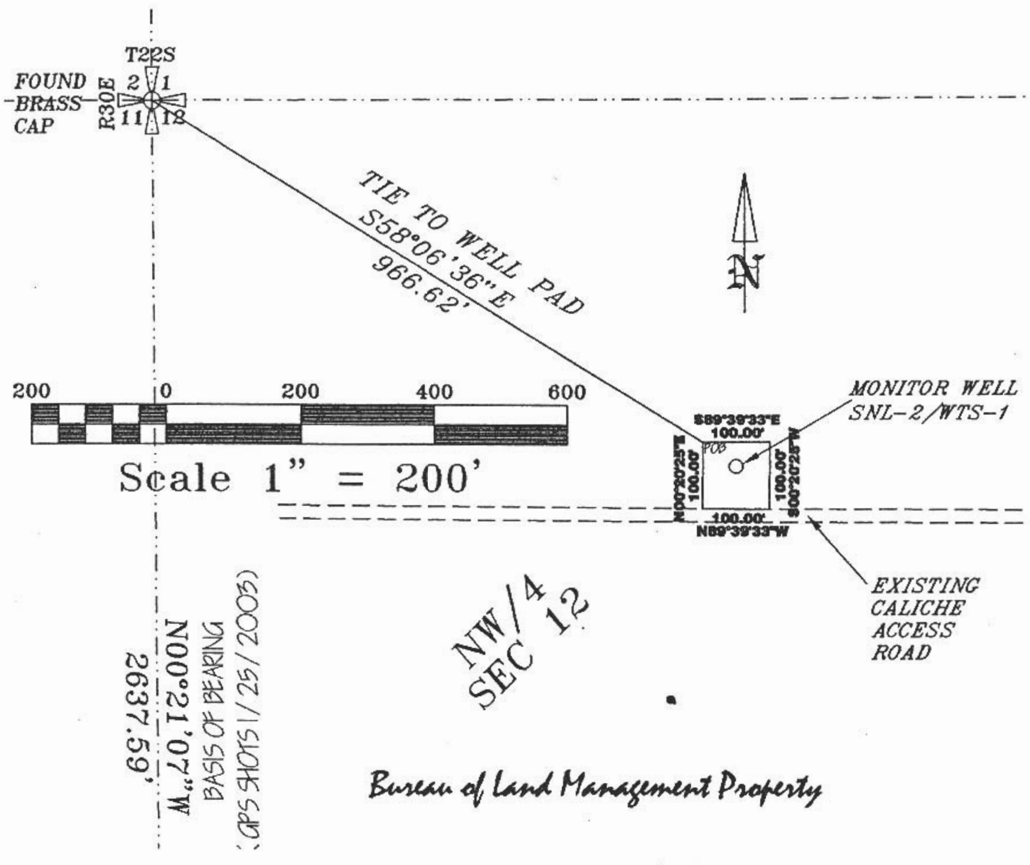


EXHIBIT A

FOR: DEPARTMENT OF ENERGY
FROM: BUREAU OF LAND MANAGEMENT

FOR A MONITOR WELL PAD, IN FAVOR OF THE DEPARTMENT OF ENERGY, FROM THE BUREAU OF LAND MANAGEMENT, BEING MORE PARTICULARLY DESCRIBED AS FOLLOWS: BEGINNING AT A POINT THAT LIES S58°06'36"E 966.62' FROM THE NW CORNER OF SEC 12, T22S, R30E, N.M.P.M., EDDY COUNTY, NEW MEXICO; THEN S89°39'33"E FOR 100.00'; THEN S00°20'25"W FOR 100.00'; THEN N89°39'33"W FOR 100.00'; THEN N00°20'25"E FOR 100.00' TO THE POINT OF BEGINNING.



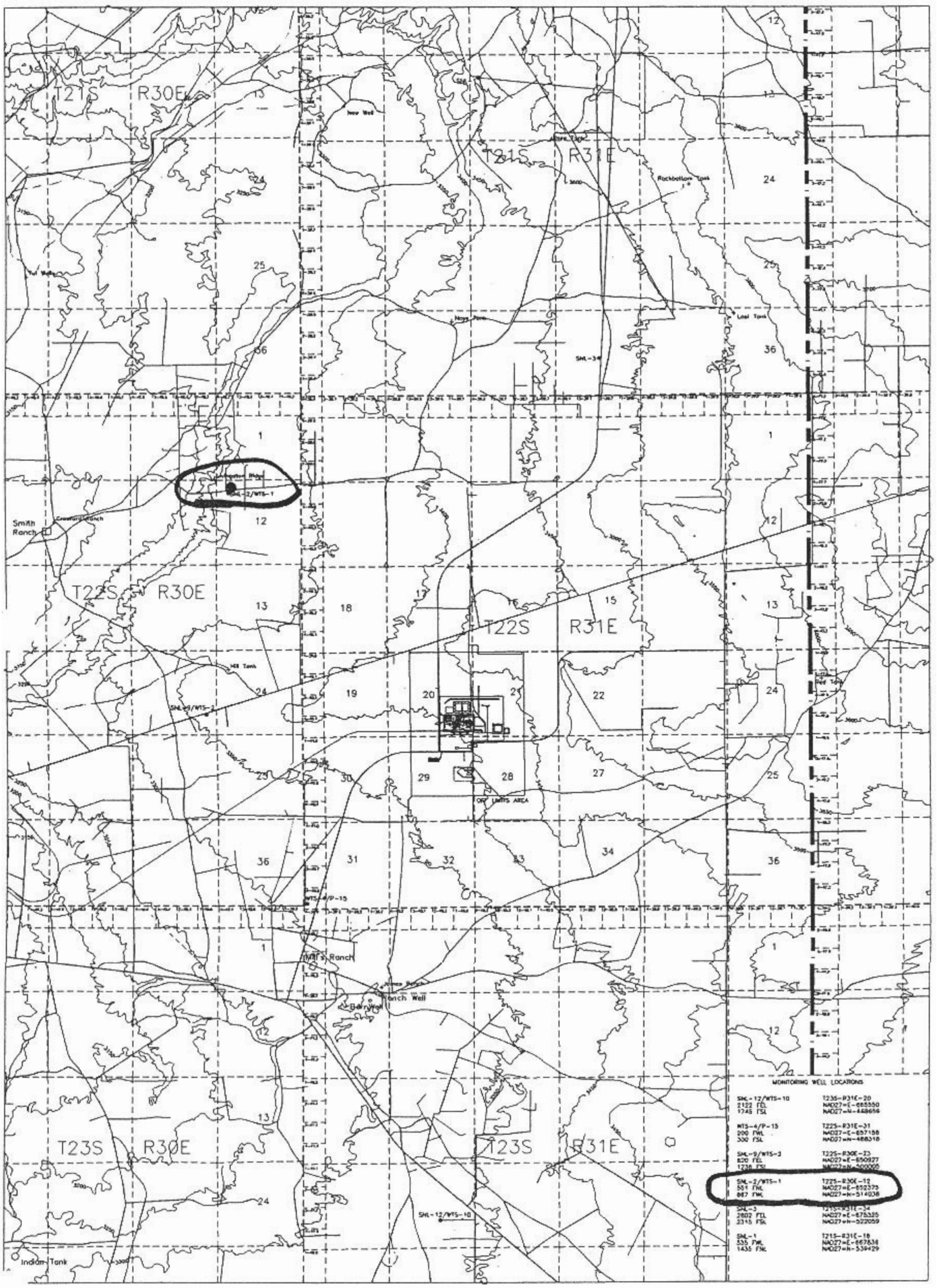
LEGEND

—··—··— LAND LINE
✣ SECTION CORNER
===== EXISTING DIRT ROAD ACCESS

THE NEW MEXICO
STATE PLANE EAST NAD27
COORDINATES FOR WELL
SNL-2/WTS-1
514044.80 N*
652356.18 E*
ELEV-3321.95*
(*SUBJECT TO CHANGE)

MELVIN R. PYEATT
8510

WELL INFORMATION		
NUMBER	SNL-2/WTS-1	
IN SEC. 12	T 22S	R 30E
COUNTY:	EDDY	
STATE:	NEW MEXICO	
DATE:	FEBRUARY 4, 2003	



551' FNL, 887' FWL, Section 12, T22S, R30E

ATTACHMENT A

MANAGEMENT OF WELL-DRILLING WASTES

Drilling fluids were taken by IW Trucking in one or more batches per mud pit (i.e., well) to Controlled Recovery, Inc. (CRI) of Hobbs, New Mexico. CRI operates both an oil field disposal pond and a non-oil field disposal pond. The drilling fluids went to the non-oil field disposal pond. The non-oil field disposal pond is lined. CRI operates under New Mexico Discharge Permit DP-818, and per this permit, disposal of well drilling fluids is allowed. CRI's permit is currently in force during its renewal by the New Mexico Environment Department. There are no current violations or outstanding action orders connected with this facility.

CRI may accept waste based on analysis or process knowledge. CRI accepted the drilling fluids based on process knowledge provided by the driller, West Texas Water Wells, of Odessa, Texas. West Texas Water Wells signed all certificates of origin as generator of the waste, and indicated that the fluids were from WIPP wells. The following quantities were received by CRI:

Well Number	**SNL-2**
Date Received:	May 16, 2003
Number of Transports	One (1)
Total Volume of Drilling Fluid	4,820 gallons (110 barrels)

Well Number	**SNL-3**
Date Received:	September 19, 20033
Number of Transports	Three (3)
Total Volume of Drilling Fluid	15,120 gallons (360 barrels)

Well Number	**SNL-9**
Date Received:	June 25, 2003
Number of Transports	Two (2)
Total Volume of Drilling Fluid	5,670 gallons (135 barrels)

Well Number	**SNL-12**
Date Received:	August 4, 2003
Number of Transports	Three (3)
Total Volume of Drilling Fluid	15,876 gallons (378 barrels)

ATTACHMENT B

CERTIFICATES OF ORIGIN

CONTROLLED RECOVERY, INC.
P.O. Box 388 • Hobbs, New Mexico 88241-0388
(505) 393-1079

ill to
Address

Company/Generator ~~WIPP~~ SE WEST TEXAS WATER WELL SERVICE
Lease Name WIPP SL#1 (this is actually SNL-2) - [illegible] 09/18/2003
Trucking Company I & W | Vehicle Number 1203 | Driver (Print) TRACY
Date 5-16-03 | Time 11:35 [✓ a.m.] / p.m.

Type of Material

☐ Exempt ☐ Tank Bottoms ☐ Fluids
☐ Non-Exempt C117 ☐ Other Material
C138 ☐ Soils List Description Below

NMED C

DESCRIPTION

MUD & FRESH WATER

Volume of Material ☑ Bbls. 110 ☐ Yard ☐ Gallons
☒ Wash Out ☐ Call Out ☐ After Hours ☐ Debris Charge

This statement applicable to exempt waste only.
I represent and warrant that the wastes are: generated from oil and gas exploration and production operations: exempt from Resource Conservation and Recover Act (RCRA) Subtitle C Regulations; and not mixed with non-exempt wastes.

Agent
(Signature)

CRI Representative
(Signature)

TANK BOTTOMS

	Feet	Inches			
1st Gauge			BBLS Received		BS&W %
2nd Gauge			Free Water		
Received			Total Received		

№ 46213

White - CRI Canary - CRI Accounting Pink - CRI Plant Gold - Transporter

SUPERIOR PRINTING SERVICE, INC.

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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 Washington Regulatory and Environmental Services, Land Management Division, for the WIPP Project.

TITLE PAGE/ABSTRACT/
NEGATIVE SITE REPORT
BLM/CFO
CARLSBAD FIELD OFFICE

1. BLM Report No.:

2. (ACCEPTED)   (REJECTED)

3. NMCRIS No.: 82098

4. Title of Report (Project Title): An Archaeological Survey for a the SNL-2/WTS-1 Water Monitoring Well

5. Project Date(s):
January 30, 2003

6. Report Date:
February 7, 2003

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

8. Permit No.: 153-2920-02-L

9. Consultant Report No.:
MFS – 822

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

11. For BLM use only

12. Acreage
Total acres surveyed: 0.92
Per Surface Ownership
Federal: 0.92
State: 0
Private: 0

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 22S, R 30E, Section 12: NE¼ NW¼ 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: N/A
Surveyed: N/A

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): Three previously recorded sites (LA 70102, LA 79984, and LA 88325) are located within 0.25 miles of the project area. One of these sites, LA 88325, is within 500 ft but will not be impacted.

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, for a total of a 200 ft by 200 ft area was surveyed to ensure the protection of cultural resources. The project area totaled 0.92 acres, all of which is on land owned and administered by the BLM-CFO. An existing caliche capped road that runs along the south boundary of the well pad will serve as access.

c. Environmental Setting (NRCS soil designation, vegetative community, etc.): The project is located within a dune field. The soil is a light brown sand with caliche nodules wind worked into dunes up to 30 cm high. It is of the Kermit-Berino soil association as defined by the Soil Conservation Service of the U.S. Department of Agriculture. Project elevations average 3,320 ft above mean sea level. Local vegetation is characteristic of Chihuahuan Desert Scrub and includes mesquite, althorn, snakeweed, bunch grasses, yucca, and prickly pear. Due to this vegetative cover, ground surface visibility averaged 70 percent.

d. Field Methods
Transect Intervals: 15 m
Crew Size: 1
Time in Field: 1 hour
Collections: None

15. Cultural Resource Findings: No cultural resources were observed within the project area.
Identification and Description (location shown on project map):

16. Management Summary (recommendations): Because no cultural material was encountered, archaeological clearance is recommended for the project area as staked. If any 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-2/WTS-1 Water Monitoring Well

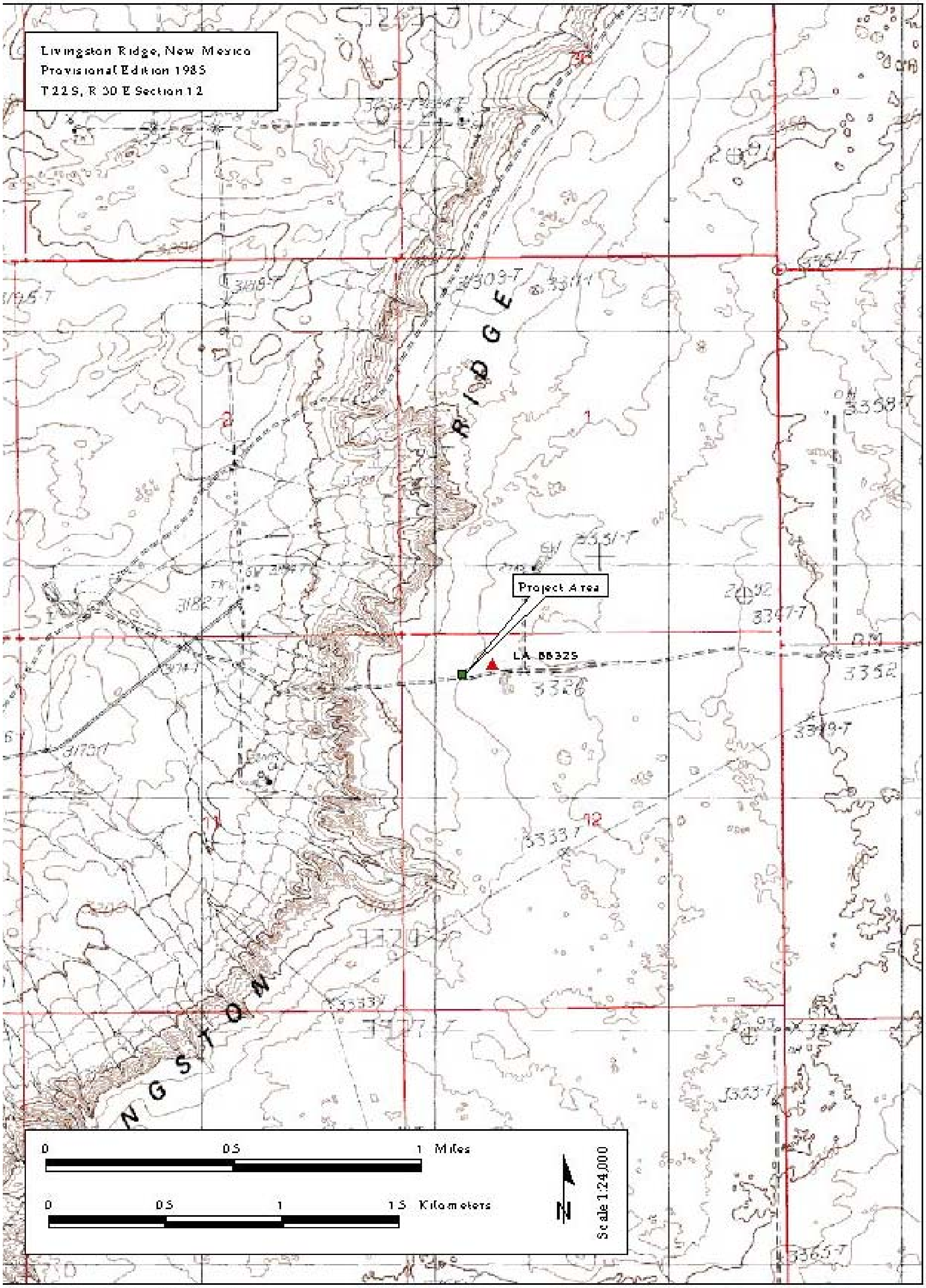

Figure 1. Project Area Map

Mesa Field Services

Appendix G
Photograph Logs

Digital photographs were taken of the cores from SNL-2. 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 Salado Formation). Most of the photographs were taken in the field shortly after recovery. Some images that were of poor quality or were accidentally overwritten were retaken while in the core box. 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-2_Core001.jpg	4-30-03	SNL-2 drillpad; T22S, R30E, Sec12	Close-up photo of Forty-niner Mbr core, 328.0 – 329.1 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-2_Core002.jpg	4-30-03	SNL-2 drillpad; T22S, R30E, Sec12	Close-up photo of Forty-niner Mbr core, 328.6 – 330.0 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-2_Core003.jpg	4-30-03	SNL-2 drillpad; T22S, R30E, Sec12	Close-up photo of Forty-niner Mbr core, 329.5 – 330.9 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-2_Core004.jpg	4-30-03	SNL-2 drillpad; T22S, R30E, Sec12	Close-up photo of Forty-niner Mbr core, 330.5 – 331.9 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-2_Core005.jpg	4-30-03	SNL-2 drillpad; T22S, R30E, Sec12	Close-up photo of Forty-niner Mbr core, 331.4 – 332.8 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-2_Core006.jpg	4-30-03	SNL-2 drillpad; T22S, R30E, Sec12	Close-up photo of Forty-niner Mbr core, 332.4 – 333.7 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-2_Core007.jpg	4-30-03	SNL-2 drillpad; T22S, R30E, Sec12	Close-up photo of Forty-niner Mbr core, 333.3 – 334.7 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-2_Core008.jpg	4-30-03	SNL-2 drillpad; T22S, R30E, Sec12	Close-up photo of Forty-niner Mbr core, 334.3 – 335.6 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-2_Core009.jpg	4-30-03	SNL-2 drillpad; T22S, R30E, Sec12	Close-up photo of Forty-niner Mbr core, 335.3 – 336.7 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-2_Core010.jpg	4-30-03	SNL-2 drillpad; T22S, R30E, Sec12	Close-up photo of Forty-niner Mbr core, 336.3 – 337.7 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-2_Core011.jpg	4-30-03	SNL-2 drillpad; T22S, R30E, Sec12	Close-up photo of Forty-niner Mbr core, 337.4 – 338.8 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-2_Core012.jpg	4-30-03	SNL-2 drillpad; T22S, R30E, Sec12	Close-up photo of Forty-niner Mbr core, 338.8 – 340.1 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-2_Core013.jpg	4-30-03	SNL-2 drillpad; T22S, R30E, Sec12	Close-up photo of Forty-niner / Magenta Dolomite Mbrs core, 339.9 – 341.3 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-2_Core014.jpg	4-30-03	SNL-2 drillpad; T22S, R30E, Sec12	Close-up photo of Magenta Dolomite Mbr core, 341.0 – 342.4 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-2_Core015.jpg	4-30-03	SNL-2 drillpad; T22S, R30E, Sec12	Close-up photo of Magenta Dolomite Mbr core, 342.0 – 343.4 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS

Camera: Casio QV-3500EX **Resolution**: 2048 x 1536 **Page** 1 **of 14**

Photograph Log Sheet

FILE	DATE	LOCATION	DESCRIPTION OF SUBJECT (includes individual / group names, direction, etc., as appropriate)	PHOTOGRAPHER (initials and dept.)
SNL-2_Core016.jpg	4-30-03	SNL-2 drillpad; T22S, R30E, Sec12	Close-up photo of Magenta Dolomite Mbr core, 343.1 – 344.4 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-2_Core017.jpg	4-30-03	SNL-2 drillpad; T22S, R30E, Sec12	Close-up photo of Magenta Dolomite Mbr core, 344.0 – 345.4 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-2_Core018.jpg	4-30-03	SNL-2 drillpad; T22S, R30E, Sec12	Close-up photo of Magenta Dolomite Mbr core, 344.9 – 346.2 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-2_Core019.jpg	4-30-03	SNL-2 drillpad; T22S, R30E, Sec12	Close-up photo of Magenta Dolomite Mbr core, 345.7 – 347.1 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-2_Core020.jpg	4-30-03	SNL-2 drillpad; T22S, R30E, Sec12	Close-up photo of Magenta Dolomite Mbr core, 346.7 – 348.0 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-2_Core021.jpg	4-30-03	SNL-2 drillpad; T22S, R30E, Sec12	Close-up photo of Magenta Dolomite Mbr core, 347.6 – 349.0 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-2_Core022.jpg	4-30-03	SNL-2 drillpad; T22S, R30E, Sec12	Close-up photo of Magenta Dolomite Mbr core, 348.5 – 349.9 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-2_Core023.jpg	4-30-03	SNL-2 drillpad; T22S, R30E, Sec12	Close-up photo of Magenta Dolomite Mbr core, 349.6 – 350.9 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-2_Core024.jpg	4-30-03	SNL-2 drillpad; T22S, R30E, Sec12	Close-up photo of Magenta Dolomite Mbr core, 350.3 – 351.6 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-2_Core025.jpg	4-30-03	SNL-2 drillpad; T22S, R30E, Sec12	Close-up photo of Magenta Dolomite Mbr core, 351.2 – 352.6 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-2_Core026.jpg	4-30-03	SNL-2 drillpad; T22S, R30E, Sec12	Close-up photo of Magenta Dolomite Mbr core, 351.9 – 353.3 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-2_Core027.jpg	4-30-03	SNL-2 drillpad; T22S, R30E, Sec12	Close-up photo of Magenta Dolomite Mbr core from 353.0 – 354.3 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-2_Core028.jpg	4-30-03	SNL-2 drillpad; T22S, R30E, Sec12	Close-up photo of Magenta Dolomite Mbr core, 354.1 – 355.4 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-2_Core029.jpg	4-30-03	SNL-2 drillpad; T22S, R30E, Sec12	Close-up photo of Magenta Dolomite Mbr core, 355.1 – 356.6 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-2_Core030.jpg	4-30-03	SNL-2 drillpad; T22S, R30E, Sec12	Close-up photo of Magenta Dolomite Mbr core, 356.1 – 357.2 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS

Camera: Casio QV-3500EX **Resolution**: 2048 x 1536 **Page 2 of 14**

Photograph Log Sheet

FILE	DATE	LOCATION	DESCRIPTION OF SUBJECT (includes individual / group names, direction, etc., as appropriate)	PHOTOGRAPHER (initials and dept.)
SNL-2_Core031.jpg	4-30-03	SNL-2 drillpad; T22S, R30E, Sec12	Close-up photo of Magenta Dolomite Mbr core, 357.2 – 358.5 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-2_Core032.jpg	4-30-03	SNL-2 drillpad; T22S, R30E, Sec12	Close-up photo of Magenta Dolomite Mbr core, 358.0 – 359.4 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-2_Core033.jpg	4-30-03	SNL-2 drillpad; T22S, R30E, Sec12	Close-up photo of Magenta Dolomite Mbr core, 359.7 – 361.2 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-2_Core034.jpg	4-30-03	SNL-2 drillpad; T22S, R30E, Sec12	Close-up photo of Magenta Dolomite Mbr core, 360.4 – 362.0 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-2_Core035.jpg	4-30-03	SNL-2 drillpad; T22S, R30E, Sec12	Close-up photo of Magenta Dolomite Mbr core, 361.5 – 362.9. ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-2_Core036.jpg	4-30-03	SNL-2 drillpad; T22S, R30E, Sec12	Close-up photo of Magenta Dolomite / Tamarisk Mbrs core, 362.5 – 364.0.ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-2_Core037.jpg	4-30-03	SNL-2 drillpad; T22S, R30E, Sec12	Close-up photo of Tamarisk Mbr core from 363.7 – 365.1. ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-2_Core038.jpg	4-30-03	SNL-2 drillpad; T22S, R30E, Sec12	Close-up photo of Tamarisk Mbr core, 364.8 – 366.4. ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-2_Core039.jpg	4-30-03	SNL-2 drillpad; T22S, R30E, Sec12	Close-up photo of Tamarisk Mbr core from 365.9 – 367.3. ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-2_Core040.jpg	4-30-03	SNL-2 drillpad; T22S, R30E, Sec12	Close-up photo of Tamarisk Mbr core, 367.4 – 369.0. ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-2_Core041.jpg	4-30-03	SNL-2 drillpad; T22S, R30E, Sec12	Close-up photo of Tamarisk Mbr core, 368.8 – 370.4. ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-2_Core042.jpg	4-30-03	SNL-2 drillpad; T22S, R30E, Sec12	Close-up photo of Tamarisk Mbr core, 370.4 – 372.0. ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-2_Core043.jpg	4-30-03	SNL-2 drillpad; T22S, R30E, Sec12	Close-up photo of Tamarisk Mbr core, 370.8 – 372.3. ft bgl, with markings, scale, and timedate stamp	-DW Powers Consultant to WTS
SNL-2_Core044.jpg	5-01-03	SNL-2 drillpad; T22S, R30E, Sec12	Close-up photo of Tamarisk Mbr core, 420.0 – 421.2. ft bgl, with markings, scale, and timedate stamp	-DW Powers Consultant to WTS
SNL-2_Core045.jpg	5-01-03	SNL-2 drillpad; T22S, R30E, Sec12	Close-up photo of Tamarisk Mbr core, 420.7 – 422.2. ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS

Photograph Log Sheet

FILE	DATE	LOCATION	DESCRIPTION OF SUBJECT (includes individual / group names, direction, etc., as appropriate)	PHOTOGRAPHER (initials and dept.)
SNL-2_Core046.jpg	5-01-03	SNL-2 drillpad; T22S, R30E, Sec12	Close-up photo of Tamarisk Mbr core, 421.7 – 423.1. ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-2_Core047.jpg	5-01-03	SNL-2 drillpad; T22S, R30E, Sec12	Close-up photo of Tamarisk Mbr core, 422.8 – 424.2. ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-2_Core048.jpg	5-01-03	SNL-2 drillpad; T22S, R30E, Sec12	Close-up photo of Tamarisk Mbr core, 423.9 – 425.3. ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-2_Core049.jpg	5-01-03	SNL-2 drillpad; T22S, R30E, Sec12	Close-up photo of Tamarisk Mbr core, 424.8 – 426.2. ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-2_Core050.jpg	5-01-03	SNL-2 drillpad; T22S, R30E, Sec12	Close-up photo of Tamarisk Mbr core, 425.8 – 427.2. ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-2_Core051.jpg	5-01-03	SNL-2 drillpad; T22S, R30E, Sec12	Close-up photo of Tamarisk Mbr core, 426.8 – 428.1. ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-2_Core052.jpg	5-01-03	SNL-2 drillpad; T22S, R30E, Sec12	Close-up photo of Tamarisk Mbr core, 427.9 – 429.2. ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-2_Core053.jpg	5-01-03	SNL-2 drillpad; T22S, R30E, Sec12	Close-up photo of Tamarisk Mbr core, 428.8 – 430.1. ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-2_Core054.jpg	5-01-03	SNL-2 drillpad; T22S, R30E, Sec12	Close-up photo of Tamarisk Mbr core, 429.8 – 431.0. ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-2_Core055.jpg	5-01-03	SNL-2 drillpad; T22S, R30E, Sec12	Close-up photo of Tamarisk Mbr core, 430.8 – 432.1 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-2_Core056.jpg	5-01-03	SNL-2 drillpad; T22S, R30E, Sec12	Close-up photo of Tamarisk Mbr core, 431.9 – 433.1. ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-2_Core057.jpg	5-01-03	SNL-2 drillpad; T22S, R30E, Sec12	Close-up photo of Tamarisk Mbr core, 432.9 – 434.1. ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-2_Core058.jpg	5-01-03	SNL-2 drillpad; T22S, R30E, Sec12	Close-up photo of Tamarisk Mbr core, 433.9 – 435.1. ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-2_Core059.jpg	5-01-03	SNL-2 drillpad; T22S, R30E, Sec12	Close-up photo of Tamarisk Mbr core, 434.7 – 436.0. ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-2_Core060.jpg	5-01-03	SNL-2 drillpad; T22S, R30E, Sec12	Close-up photo of Tamarisk Mbr core, 435.8 – 437.0. ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS

Camera: Casio QV-3500EX **Resolution**: 2048 x 1536 **Page** 4 **of 14**

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FILE	DATE	LOCATION	DESCRIPTION OF SUBJECT (includes individual / group names, direction, etc., as appropriate)	PHOTOGRAPHER (initials and dept.)
SNL-2_Core061.jpg	5-01-03	SNL-2 drillpad; T22S, R30E, Sec12	Close-up photo of Tamarisk Mbr core, 436.9 – 438.1. ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-2_Core062.jpg	5-01-03	SNL-2 drillpad; T22S, R30E, Sec12	Close-up photo of Tamarisk Mbr core, 437.8 – 439.1. ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-2_Core063.jpg	5-01-03	SNL-2 drillpad; T22S, R30E, Sec12	Close-up photo of Tamarisk Mbr core, 438.9 – 440.2. ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-2_Core064.jpg	5-01-03	SNL-2 drillpad; T22S, R30E, Sec12	Close-up photo of Tamarisk Mbr core, 439.9 – 441.1. ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-2_Core065.jpg	5-01-03	SNL-2 drillpad; T22S, R30E, Sec12	Close-up photo of Tamarisk Mbr core, 440.9 – 442.1. ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-2_Core066.jpg	5-01-03	SNL-2 drillpad; T22S, R30E, Sec12	Close-up photo of Tamarisk Mbr core, 441.9 – 443.1. ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-2_Core067.jpg	5-01-03	SNL-2 drillpad; T22S, R30E, Sec12	Close-up photo of Tamarisk Mbr core, 442.8 – 444.1. ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-2_Core068.jpg	5-01-03	SNL-2 drillpad; T22S, R30E, Sec12	Close-up photo of Tamarisk Mbr core, 443.9 – 445.1. ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-2_Core069.jpg	5-01-03	SNL-2 drillpad; T22S, R30E, Sec12	Close-up photo of Tamarisk Mbr core, 444.9 – 446.2. ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-2_Core070.jpg	5-01-03	SNL-2 drillpad; T22S, R30E, Sec12	Close-up photo of Tamarisk Mbr core, 445.9 – 447.2. ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-2_Core071.jpg	5-01-03	SNL-2 drillpad; T22S, R30E, Sec12	Close-up photo of Tamarisk Mbr core, 446.8 – 448.2. ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-2_Core072.jpg	5-01-03	SNL-2 drillpad; T22S, R30E, Sec12	Close-up photo of Tamarisk Mbr core, 447.6 – 448.6. ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-2_Core073.jpg	5-01-03	SNL-2 drillpad; T22S, R30E, Sec12	Close-up photo of Tamarisk Mbr core, 448.6 – 449.9. ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-2_Core074.jpg	5-01-03	SNL-2 drillpad; T22S, R30E, Sec12	Close-up photo of Tamarisk Mbr core, 449.6 – 451.0. ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-2_Core075.jpg	5-01-03	SNL-2 drillpad; T22S, R30E, Sec12	Close-up photo of Tamarisk Mbrcore, 450.7 – 452.1. ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS

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FILE	**DATE**	**LOCATION**	**DESCRIPTION OF SUBJECT** (includes individual / group names, direction, etc., as appropriate)	**PHOTOGRAPHER** (initials and dept.)
SNL-2_Core076.jpg	5-01-03	SNL-2 drillpad; T22S, R30E, Sec12	Close-up photo of Tamarisk Mbr core, 451.8 – 453.2. ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-2_Core077.jpg	5-01-03	SNL-2 drillpad; T22S, R30E, Sec12	Close-up photo of Tamarisk Mbr core, 452.9 – 454.3. ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-2_Core078.jpg	5-01-03	SNL-2 drillpad; T22S, R30E, Sec12	Close-up photo of Tamarisk Mbr core, 453.8 – 455.2 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-2_Core079.jpg	5-01-03	SNL-2 drillpad; T22S, R30E, Sec12	Close-up photo of Tamarisk / Culebra Dolomite Mbrs core, 454.9 – 456.2. ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-2_Core080.jpg	5-01-03	SNL-2 drillpad; T22S, R30E, Sec12	Close-up photo of Culebra Dolomite Mbrs core, 455.6 – 457.0. ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-2_Core081.jpg	5-01-03	SNL-2 drillpad; T22S, R30E, Sec12	Close-up photo of Culebra Dolomite Mbrs core, 456.6 – 458.0. ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-2_Core082.jpg	5-01-03	SNL-2 drillpad; T22S, R30E, Sec12	Close-up photo of Culebra Dolomite Mbr core, 457.7 – 459.0. ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-2_Core083.jpg	5-01-03	SNL-2 drillpad; T22S, R30E, Sec12	Close-up photo of Culebra Dolomite Mbr core, 458.7 – 460.1. ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-2_Core084.jpg	5-01-03	SNL-2 drillpad; T22S, R30E, Sec12	Close-up photo of Culebra Dolomite Mbr core, 459.8 – 461.1. ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-2_Core085.jpg	5-01-03	SNL-2 drillpad; T22S, R30E, Sec12	Close-up photo of Culebra Dolomite Mbr core, 460.8 – 462.2. ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-2_Core086.jpg	5-01-03	SNL-2 drillpad; T22S, R30E, Sec12	Close-up photo of Culebra Dolomite Mbr core, 461.9 – 463.4. ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-2_Core087.jpg	5-01-03	SNL-2 drillpad; T22S, R30E, Sec12	Close-up photo of Culebra Dolomite Mbr core, 462.8 – 464.0 ft bgl, with markings, scale, and time-date stamp	DW Powers Consultant to WTS
SNL-2_Core088.jpg	5-01-03	SNL-2 drillpad; T22S, R30E, Sec12	Close-up photo of Culebra Dolomite Mbr core, 476.1 – 477.4 ft bgl, with markings, scale and time-date stamp	DW Powers Consultant to WTS
SNL-2_Core089.jpg	5-01-03	SNL-2 drillpad; T22S, R30E, Sec12	Close-up photo of Culebra Dolomite Mbr core, 477.1 – 478.6 ft bgl, with markings, scale and time-date stamp	DW Powers Consultant to WTS
SNL-2_Core090.jpg	5-01-03	SNL-2 drillpad; T22S, R30E, Sec12	Close-up photo of Culebra Dolomite Mbr core, 478.4 – 479.8 ft bgl, with markings, scale and time-date stamp	DW Powers Consultant to WTS

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FILE	DATE	LOCATION	DESCRIPTION OF SUBJECT (includes individual / group names, direction, etc., as appropriate)	PHOTOGRAPHER (initials and dept.)
SNL-2_Core091.jpg	5-01-03	SNL-2 drillpad; T22S, R30E, Sec12	Close-up photo of Culebra Dolomite Mbr core, 479.5 – 481.0 ft bgl, with markings, scale and time-date stamp	DW Powers Consultant to WTS
SNL-2_Core092.jpg	5-01-03	SNL-2 drillpad; T22S, R30E, Sec12	Close-up photo of Culebra Dolomite Mbr core, 480.7 – 482.2 ft bgl, with markings, scale and time-date stamp	DW Powers Consultant to WTS
SNL-2_Core093.jpg	5-01-03	SNL-2 drillpad; T22S, R30E, Sec12	Close-up photo of Culebra Dolomite Mbr core, 481.8 – 483.4 ft bgl, with markings, scale and time-date stamp	DW Powers Consultant to WTS
SNL-2_Core094.jpg	5-01-03	SNL-2 drillpad; T22S, R30E, Sec12	Close-up photo of Culebra Dolomite Mbr core, 483.2 – 484.7 ft bgl, with markings, scale and time-date stamp	DW Powers Consultant to WTS
SNL-2_Core095.jpg	5-01-03	SNL-2 drillpad; T22S, R30E, Sec12	Close-up photo of Culebra Dolomite / Los Medaños Mbrs core, 484.0 – 485.1 ft bgl, with markings, scale and time-date stamp	DW Powers Consultant to WTS
SNL-2_Core096.jpg	5-02-03	SNL-2 drillpad; T22S, R30E, Sec12	Close-up photo of Los Medaños Mbr core, 489.4 – 490.6 ft bgl, with markings, scale and time-date stamp	DW Powers Consultant to WTS
SNL-2_Core097.jpg	5-02-03	SNL-2 drillpad; T22S, R30E, Sec12	Close-up photo of Los Medaños Mbr core, 489.8 – 491.4 ft bgl, with markings, scale and time-date stamp	DW Powers Consultant to WTS
SNL-2_Core098.jpg	5-02-03	SNL-2 drillpad; T22S, R30E, Sec12	Close-up photo of Los Medaños Mbr core, 490.8 – 492.4 ft bgl, with markings, scale and time-date stamp	DW Powers Consultant to WTS
SNL-2_Core099.jpg	5-02-03	SNL-2 drillpad; T22S, R30E, Sec12	Close-up photo of Los Medaños Mbr core, 491.6 – 493.2 ft bgl, with markings, scale and time-date stamp	DW Powers Consultant to WTS
SNL-2_Core100.jpg	5-02-03	SNL-2 drillpad; T22S, R30E, Sec12	Close-up photo of Los Medaños Mbr core, 492.7 – 494.2 ft bgl, with markings, scale and time-date stamp	DW Powers Consultant to WTS
SNL-2_Core101.jpg	5-02-03	SNL-2 drillpad; T22S, R30E, Sec12	Close-up photo of Los Medaños Mbr core, 493.8 – 495.2 ft bgl, with markings, scale and time-date stamp	DW Powers Consultant to WTS
SNL-2_Core102.jpg	5-02-03	SNL-2 drillpad; T22S, R30E, Sec12	Close-up photo of Los Medaños Mbr core, 494.8 – 496.2 ft bgl, with markings, scale and time-date stamp	DW Powers Consultant to WTS
SNL-2_Core103.jpg	5-02-03	SNL-2 drillpad; T22S, R30E, Sec12	Close-up photo of Los Medaños Mbr core, 495.7 – 497.2 ft bgl, with markings, scale and time-date stamp	DW Powers Consultant to WTS
SNL-2_Core104.jpg	5-02-03	SNL-2 drillpad; T22S, R30E, Sec12	Close-up photo of Los Medaños Mbr core, 496.7 – 498.2 ft bgl, with markings, scale and time-date stamp	DW Powers Consultant to WTS
SNL-2_Core105.jpg	5-02-03	SNL-2 drillpad; T22S, R30E, Sec12	Close-up photo of Los Medaños Mbr core, 497.7 – 499.2 ft bgl, with markings, scale and time-date stamp	DW Powers Consultant to WTS

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FILE	DATE	LOCATION	DESCRIPTION OF SUBJECT (includes individual / group names, direction, etc., as appropriate)	PHOTOGRAPHER (initials and dept.)
SNL-2_Core106.jpg	5-02-03	SNL-2 drillpad; T22S, R30E, Sec12	Close-up photo of Los Medaños Mbr core, 498.7 – 500.2 ft bgl, with markings, scale and time-date stamp	DW Powers Consultant to WTS
SNL-2_Core107.jpg	5-02-03	SNL-2 drillpad; T22S, R30E, Sec12	Close-up photo of Los Medaños Mbr core, 499.8 – 501.2 ft bgl, with markings, scale and time-date stamp	DW Powers Consultant to WTS
SNL-2_Core108.jpg	5-02-03	SNL-2 drillpad; T22S, R30E, Sec12	Close-up photo of Los Medaños Mbr core, 500.8 – 502.3 ft bgl, with markings, scale and time-date stamp	DW Powers Consultant to WTS
SNL-2_Core109.jpg	5-02-03	SNL-2 drillpad; T22S, R30E, Sec12	Close-up photo of Los Medaños Mbr core, 501.8 – 503.2 ft bgl, with markings, scale and time-date stamp	DW Powers Consultant to WTS
SNL-2_Core110.jpg	5-02-03	SNL-2 drillpad; T22S, R30E, Sec12	Close-up photo of Los Medaños Mbr core, 502.8 – 504.3 ft bgl, with markings, scale and time-date stamp	DW Powers Consultant to WTS
SNL-2_Core111.jpg	5-02-03	SNL-2 drillpad; T22S, R30E, Sec12	Close-up photo of Los Medaños Mbr core, 503.9 – 505.6 ft bgl, with markings, scale and time-date stamp	DW Powers Consultant to WTS
SNL-2_Core112.jpg	5-01-03	SNL-2 drillpad; T22S, R30E, Sec12	Close-up photo of Los Medaños Mbr core, 505.2 – 506.7 ft bgl, with markings, scale and time-date stamp	DW Powers Consultant to WTS
SNL-2_Core113.jpg	5-02-03	SNL-2 drillpad; T22S, R30E, Sec12	Close-up photo of Los Medaños Mbr core, 506.4 – 507.9 ft bgl, with markings, scale and time-date stamp	DW Powers Consultant to WTS
SNL-2_Core114.jpg	5-02-03	SNL-2 drillpad; T22S, R30E, Sec12	Close-up photo of Los Medaños Mbr core, 507.9 – 509.3 ft bgl, with markings, scale and time-date stamp	DW Powers Consultant to WTS
SNL-2_Core115.jpg	5-02-03	SNL-2 drillpad; T22S, R30E, Sec12	Close-up photo of Los Medaños Mbr core, 509.1 – 510.5 ft bgl, with markings, scale and time-date stamp	DW Powers Consultant to WTS
SNL-2_Core116.jpg	5-02-03	SNL-2 drillpad; T22S, R30E, Sec12	Close-up photo of Los Medaños Mbr core, 510.0 – 511.7 ft bgl, with markings, scale and time-date stamp	DW Powers Consultant to WTS
SNL-2_Core117.jpg	5-02-03	SNL-2 drillpad; T22S, R30E, Sec12	Close-up photo of Los Medaños Mbr core, 510.8 – 512.0 ft bgl, with markings, scale and time-date stamp	DW Powers Consultant to WTS
SNL-2_Core118.jpg	5-02-03	SNL-2 drillpad; T22S, R30E, Sec12	Close-up photo of Los Medaños Mbr core, 526.9 – 528.3 ft bgl, with markings, scale and time-date stamp	DW Powers Consultant to WTS
SNL-2_Core119.jpg	5-02-03	SNL-2 drillpad; T22S, R30E, Sec12	Close-up photo of Los Medaños Mbr core, 528.0 – 529.3 ft bgl, with markings, scale and time-date stamp	DW Powers Consultant to WTS
SNL-2_Core120.jpg	5-02-03	SNL-2 drillpad; T22S, R30E, Sec12	Close-up photo of Los Medaños Mbr core, 528.9 – 530.2 ft bgl, with markings, scale and time-date stamp	DW Powers Consultant to WTS

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FILE	DATE	LOCATION	DESCRIPTION OF SUBJECT (includes individual / group names, direction, etc., as appropriate)	PHOTOGRAPHER (initials and dept.)
SNL-2_Core121.jpg	5-02-03	SNL-2 drillpad; T22S, R30E, Sec12	Close-up photo of Los Medaños Mbr core, 529.5 – 530.9 ft bgl, with markings, scale and time-date stamp	DW Powers Consultant to WTS
SNL-2_Core122.jpg	5-02-03	SNL-2 drillpad; T22S, R30E, Sec12	Close-up photo of Los Medaños Mbr core, 529.8 – 531.1 ft bgl, with markings, scale and time-date stamp	DW Powers Consultant to WTS
SNL-2_Core123.jpg	5-02-03	SNL-2 drillpad; T22S, R30E, Sec12	Close-up photo of Los Medaños Mbr core, 530.3 – 531.5 ft bgl, with markings, scale and time-date stamp	DW Powers Consultant to WTS
SNL-2_Core124.jpg	5-02-03	SNL-2 drillpad; T22S, R30E, Sec12	Close-up photo of Los Medaños Mbr core, 530.5 – 531.8 ft bgl, with markings, scale and time-date stamp	DW Powers Consultant to WTS
SNL-2_Core125.jpg	5-02-03	SNL-2 drillpad; T22S, R30E, Sec12	Close-up photo of Los Medaños Mbr core, 531.3 – 532.6 ft bgl, with markings, scale and time-date stamp	DW Powers Consultant to WTS
SNL-2_Core126.jpg	5-02-03	SNL-2 drillpad; T22S, R30E, Sec12	Close-up photo of Los Medaños Mbr core, 532.1 – 533.4 ft bgl, with markings, scale and time-date stamp	DW Powers Consultant to WTS
SNL-2_Core127.jpg	5-02-03	SNL-2 drillpad; T22S, R30E, Sec12	Close-up photo of Los Medaños Mbr core, 533.0 – 534.3 ft bgl, with markings, scale and time-date stamp	DW Powers Consultant to WTS
SNL-2_Core128.jpg	5-02-03	SNL-2 drillpad; T22S, R30E, Sec12	Close-up photo of Los Medaños Mbr core, 533.9 – 535.2 ft bgl, with markings, scale and time-date stamp	DW Powers Consultant to WTS
SNL-2_Core129.jpg	5-02-03	SNL-2 drillpad; T22S, R30E, Sec12	Close-up photo of Los Medaños Mbr core, 534.8 – 536.1 ft bgl, with markings, scale and time-date stamp	DW Powers Consultant to WTS
SNL-2_Core130.jpg	5-02-03	SNL-2 drillpad; T22S, R30E, Sec12	Close-up photo of Los Medaños Mbr core, 535.8 – 537.1 ft bgl, with markings, scale and time-date stamp	DW Powers Consultant to WTS
SNL-2_Core131.jpg	5-02-03	SNL-2 drillpad; T22S, R30E, Sec12	Close-up photo of Los Medaños Mbr core, 536.8 – 538.0 ft bgl, with markings, scale and time-date stamp	DW Powers Consultant to WTS
SNL-2_Core132.jpg	5-02-03	SNL-2 drillpad; T22S, R30E, Sec12	Close-up photo of Los Medaños Mbr core, 537.8 – 539.1 ft bgl, with markings, scale and time-date stamp	DW Powers Consultant to WTS
SNL-2_Core133.jpg	5-02-03	SNL-2 drillpad; T22S, R30E, Sec12	Close-up photo of Los Medaños Mbr core, 538.8 – 540.1 ft bgl, with markings, scale and time-date stamp	DW Powers Consultant to WTS
SNL-2_Core134.jpg	5-02-03	SNL-2 drillpad; T22S, R30E, Sec12	Close-up photo of Los Medaños Mbr core, 539.7 – 541.0 ft bgl, with markings, scale and time-date stamp	DW Powers Consultant to WTS
SNL-2_Core135.jpg	5-02-03	SNL-2 drillpad; T22S, R30E, Sec12	Close-up photo of Los Medaños Mbr core, 540.6 – 542.0 ft bgl, with markings, scale and time-date stamp	DW Powers Consultant to WTS

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FILE	DATE	LOCATION	DESCRIPTION OF SUBJECT (includes individual / group names, direction, etc., as appropriate)	PHOTOGRAPHER (initials and dept.)
SNL-2_Core136.jpg	5-02-03	SNL-2 drillpad; T22S, R30E, Sec12	Close-up photo of Los Medaños Mbr core, 542.6 – 543.7 ft bgl, with markings, scale and time-date stamp	DW Powers Consultant to WTS
SNL-2_Core137.jpg	5-02-03	SNL-2 drillpad; T22S, R30E, Sec12	Close-up photo of Los Medaños Mbr core, 542.8 – 544.2 ft bgl, with markings, scale and time-date stamp	DW Powers Consultant to WTS
SNL-2_Core138.jpg	5-02-03	SNL-2 drillpad; T22S, R30E, Sec12	Close-up photo of Los Medaños Mbr core, 543.7 – 545.2 ft bgl, with markings, scale and time-date stamp	DW Powers Consultant to WTS
SNL-2_Core139.jpg	5-05-03	SNL-2 drillpad; T22S, R30E, Sec12	Close-up photo of Los Medaños Mbr core, 544.9 – 546.2 ft bgl, with markings, scale and time-date stamp	DW Powers Consultant to WTS
SNL-2_Core140.jpg	5-05-03	SNL-2 drillpad; T22S, R30E, Sec12	Close-up photo of Los Medaños Mbr core, 545.8 – 547.1 ft bgl, with markings, scale and time-date stamp	DW Powers Consultant to WTS
SNL-2_Core141.jpg	5-05-03	SNL-2 drillpad; T22S, R30E, Sec12	Close-up photo of Los Medaños Mbr core, 546.7 – 548.0 ft bgl, with markings, scale and time-date stamp	DW Powers Consultant to WTS
SNL-2_Core142.jpg	5-05-03	SNL-2 drillpad; T22S, R30E, Sec12	Close-up photo of Los Medaños Mbr core, 547.8 – 549.1 ft bgl, with markings, scale and time-date stamp	DW Powers Consultant to WTS
SNL-2_Core143.jpg	5-05-03	SNL-2 drillpad; T22S, R30E, Sec12	Close-up photo of Los Medaños Mbr core, 548.7 – 550.2 ft bgl, with markings, scale and time-date stamp	DW Powers Consultant to WTS
SNL-2_Core144.jpg	5-05-03	SNL-2 drillpad; T22S, R30E, Sec12	Close-up photo of Los Medaños Mbr core, 549.7 – 551.2 ft bgl, with markings, scale and time-date stamp	DW Powers Consultant to WTS
SNL-2_Core145.jpg	5-05-03	SNL-2 drillpad; T22S, R30E, Sec12	Close-up photo of Los Medaños Mbr core, 550.8 – 552.1 ft bgl, with markings, scale and time-date stamp	DW Powers Consultant to WTS
SNL-2_Core146.jpg	5-05-03	SNL-2 drillpad; T22S, R30E, Sec12	Close-up photo of Los Medaños Mbr core, 551.6 – 553.0 ft bgl, with markings, scale and time-date stamp	DW Powers Consultant to WTS
SNL-2_Core147.jpg	5-05-03	SNL-2 drillpad; T22S, R30E, Sec12	Close-up photo of Los Medaños Mbr core, 552.8 – 554.2 ft bgl, with markings, scale and time-date stamp	DW Powers Consultant to WTS
SNL-2_Core148.jpg	5-05-03	SNL-2 drillpad; T22S, R30E, Sec12	Close-up photo of Los Medaños Mbr core, 553.9 – 555.2 ft bgl, with markings, scale and time-date stamp	DW Powers Consultant to WTS
SNL-2_Core149.jpg	5-05-03	SNL-2 drillpad; T22S, R30E, Sec12	Close-up photo of Los Medaños Mbr core, 554.8 – 556.1 ft bgl, with markings, scale and time-date stamp	DW Powers Consultant to WTS

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Photograph Log Sheet

FILE	DATE	LOCATION	DESCRIPTION OF SUBJECT (includes individual / group names, direction, etc., as appropriate)	PHOTOGRAPHER (initials and dept.)
SNL-2_Core150.jpg	5-05-03	SNL-2 drillpad; T22S, R30E, Sec12	Close-up photo of Los Medaños Mbr core, 555.8 – 557.3 ft bgl, with markings, scale and time-date stamp	DW Powers Consultant to WTS
SNL-2_Core151.jpg	5-05-03	SNL-2 drillpad; T22S, R30E, Sec12	Close-up photo of Los Medaños Mbr core, 556.4 – 558.1 ft bgl, with markings, scale and time-date stamp; resolution distorted	DW Powers Consultant to WTS
SNL-2_Core152.jpg	5-05-03	SNL-2 drillpad; T22S, R30E, Sec12	Close-up photo of Los Medaños Mbr core, 557.8 – 559.2 ft bgl, with markings, scale and time-date stamp	DW Powers Consultant to WTS
SNL-2_Core153.jpg	5-05-03	SNL-2 drillpad; T22S, R30E, Sec12	Close-up photo of Los Medaños Mbr core, 559.6 – 561.1 ft bgl, with markings, scale and time-date stamp	DW Powers Consultant to WTS
SNL-2_Core154.jpg	5-05-03	SNL-2 drillpad; T22S, R30E, Sec12	Close-up photo of Los Medaños Mbr core, 560.7 – 562.1 ft bgl, with markings, scale and time-date stamp	DW Powers Consultant to WTS
SNL-2_Core155.jpg	5-05-03	SNL-2 drillpad; T22S, R30E, Sec12	Close-up photo of Los Medaños Mbr core, 561.8 – 563.2 ft bgl, with markings, scale and time-date stamp	DW Powers Consultant to WTS
SNL-2_Core156.jpg	5-05-03	SNL-2 drillpad; T22S, R30E, Sec12	Close-up photo of Los Medaños Mbr core, 562.8 – 564.2 ft bgl, with markings, scale and time-date stamp	DW Powers Consultant to WTS
SNL-2_Core157.jpg	5-05-03	SNL-2 drillpad; T22S, R30E, Sec12	Close-up photo of Los Medaños Mbr core, 563.8 – 565.2 ft bgl, with markings, scale and time-date stamp	DW Powers Consultant to WTS
SNL-2_Core158.jpg	5-05-03	SNL-2 drillpad; T22S, R30E, Sec12	Close-up photo of Los Medaños Mbr core, 564.8 – 566.2 ft bgl, with markings, scale and time-date stamp	DW Powers Consultant to WTS
SNL-2_Core159.jpg	5-05-03	SNL-2 drillpad; T22S, R30E, Sec12	Close-up photo of Los Medaños Mbr core, 565.7 – 567.1 ft bgl, with markings, scale and time-date stamp	DW Powers Consultant to WTS
SNL-2_Core160.jpg	5-05-03	SNL-2 drillpad; T22S, R30E, Sec12	Close-up photo of Los Medaños Mbr core, 566.8 – 568.1 ft bgl, with markings, scale and time-date stamp	DW Powers Consultant to WTS
SNL-2_Core161.jpg	5-05-03	SNL-2 drillpad; T22S, R30E, Sec12	Close-up photo of Los Medaños Mbr core, 567.8 – 569.1 ft bgl, with markings, scale and time-date stamp	DW Powers Consultant to WTS
SNL-2_Core162.jpg	5-05-03	SNL-2 drillpad; T22S, R30E, Sec12	Close-up photo of Los Medaños Mbr core, 568.8 – 570.1 ft bgl, with markings, scale and time-date stamp	DW Powers Consultant to WTS
SNL-2_Core163.jpg	5-05-03	SNL-2 drillpad; T22S, R30E, Sec12	Close-up photo of Los Medaños Mbr core, 569.8 – 571.1 ft bgl, with markings, scale and time-date stamp	DW Powers Consultant to WTS
SNL-2_Core164.jpg	5-05-03	SNL-2 drillpad; T22S, R30E, Sec12	Close-up photo of Los Medaños Mbr core, 569.9 – 571.2 ft bgl, with markings, scale and time-date stamp	DW Powers Consultant to WTS

Photograph Log Sheet

FILE	DATE	LOCATION	DESCRIPTION OF SUBJECT (includes individual / group names, direction, etc., as appropriate)	PHOTOGRAPHER (initials and dept.)
SNL-2_Core165.jpg	5-05-03	SNL-2 drillpad; T22S, R30E, Sec12	Close-up photo of Los Medaños Mbr core, 570.8 – 572.2 ft bgl, with markings, scale and time-date stamp	DW Powers Consultant to WTS
SNL-2_Core166.jpg	5-05-03	SNL-2 drillpad; T22S, R30E, Sec12	Close-up photo of Los Medaños Mbr core, 571.8 – 573.1 ft bgl, with markings, scale and time-date stamp	DW Powers Consultant to WTS
SNL-2_Core167.jpg	5-05-03	SNL-2 drillpad; T22S, R30E, Sec12	Close-up photo of Los Medaños Mbr core, 572.8 – 574.1 ft bgl, with markings, scale and time-date stamp	DW Powers Consultant to WTS
SNL-2_Core168.jpg	5-05-03	SNL-2 drillpad; T22S, R30E, Sec12	Close-up photo of Los Medaños Mbr core, 573.7 – 575.2 ft bgl, with markings, scale and time-date stamp	DW Powers Consultant to WTS
SNL-2_Core169.jpg	5-05-03	SNL-2 drillpad; T22S, R30E, Sec12	Close-up photo of Los Medaños Mbr core, 574.8 – 576.2 ft bgl, with markings, scale and time-date stamp	DW Powers Consultant to WTS
SNL-2_Core170.jpg	5-05-03	SNL-2 drillpad; T22S, R30E, Sec12	Close-up photo of Los Medaños Mbr core, 575.9 – 577.0 ft bgl, with markings, scale and time-date stamp	DW Powers Consultant to WTS
SNL-2_Core171.jpg	5-05-03	SNL-2 drillpad; T22S, R30E, Sec12	Close-up photo of Los Medaños Mbr core, 577.0 – 578.2 ft bgl, with markings, scale and time-date stamp	DW Powers Consultant to WTS
SNL-2_Core172.jpg	5-05-03	SNL-2 drillpad; T22S, R30E, Sec12	Close-up photo of Los Medaños Mbr core, 577.8 – 579.2 ft bgl, with markings, scale and time-date stamp	DW Powers Consultant to WTS
SNL-2_Core173.jpg	5-05-03	SNL-2 drillpad; T22S, R30E, Sec12	Close-up photo of Los Medaños Mbr core, 578.9 – 580.2 ft bgl, with markings, scale and time-date stamp	DW Powers Consultant to WTS
SNL-2_Core174.jpg	5-05-03	SNL-2 drillpad; T22S, R30E, Sec12	Close-up photo of Los Medaños Mbr core, 579.8 – 581.1 ft bgl, with markings, scale and time-date stamp	DW Powers Consultant to WTS
SNL-2_Core175.jpg	5-05-03	SNL-2 drillpad; T22S, R30E, Sec12	Close-up photo of Los Medaños Mbr core, 580.9 – 582.2 ft bgl, with markings, scale and time-date stamp	DW Powers Consultant to WTS
SNL-2_Core176.jpg	5-05-03	SNL-2 drillpad; T22S, R30E, Sec12	Close-up photo of Los Medaños Mbr core, 581.8 – 583.2 ft bgl, with markings, scale and time-date stamp	DW Powers Consultant to WTS
SNL-2_Core177.jpg	5-05-03	SNL-2 drillpad; T22S, R30E, Sec12	Close-up photo of Los Medaños Mbr core, 582.3 – 583.5 ft bgl, with markings, scale and time-date stamp	DW Powers Consultant to WTS
SNL-2_Core178.jpg	5-06-03	SNL-2 drillpad; T22S, R30E, Sec12	Close-up photo of Los Medaños Mbr core, 583.5 – 584.8 ft bgl, with markings, scale and time-date stamp	DW Powers Consultant to WTS
SNL-2_Core179.jpg	5-06-03	SNL-2 drillpad; T22S, R30E, Sec12	Close-up photo of Los Medaños Mbr core, 584.8 – 585.8 ft bgl, with markings, scale and time-date stamp	DW Powers Consultant to WTS

Camera: Casio QV-3500EX **Resolution**: 2048 x 1536 **Page 12 of 14**

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FILE	DATE	LOCATION	DESCRIPTION OF SUBJECT (includes individual / group names, direction, etc., as appropriate)	PHOTOGRAPHER (initials and dept.)
SNL-2_Core180.jpg	5-06-03	SNL-2 drillpad; T22S, R30E, Sec12	Close-up photo of Los Medaños Mbr core, 585.6 – 586.8 ft bgl, with markings, scale and time-date stamp	DW Powers Consultant to WTS
SNL-2_Core181.jpg	5-29-03	SNL-2 drillpad; T22S, R30E, Sec12	Close-up photo of Los Medaños Mbr / Salado Fm core, 586.8 – 588.0 ft bgl, with markings, scale and time-date stamp	DW Powers Consultant to WTS
SNL-2_Core182.jpg	5-29-03	SNL-2 drillpad; T22S, R30E, Sec12	Close-up photo of Los Medaños Mbr/Salado Fm core, 587.7 – 588.8 ft bgl, with markings, scale and time-date	DW Powers Consultant to WTS
SNL-2_Core183.jpg	5-29-03	SNL-2 drillpad; T22S, R30E, Sec12	Close-up photo of Salado Fm core, 588.8 – 590.0 ft bgl, with markings, scale and time-date stamp	DW Powers Consultant to WTS
SNL-2_Core184.jpg	5-29-03	SNL-2 drillpad; T22S, R30E, Sec12	Close-up photo of Salado Fm core, 589.6 – 590.8 ft bgl, with markings, scale and time-date stamp	DW Powers Consultant to WTS
SNL-2_Core185.jpg	5-29-03	SNL-2 drillpad; T22S, R30E, Sec12	Close-up photo of Salado Fm core, 590.8 – 591.9 ft bgl, with markings, scale and time-date stamp	DW Powers Consultant to WTS
SNL-2_Core186.jpg	5-29-03	SNL-2 drillpad; T22S, R30E, Sec12	Close-up photo of Salado Fm core, 591.5 – 592.5 ft bgl, with markings, scale and time-date stamp	DW Powers Consultant to WTS
SNL-2_Core187.jpg	5-29-03	SNL-2 drillpad; T22S, R30E, Sec12	Close-up photo of Salado Fm core, 592.5 – 593.7 ft bgl, with markings, scale and time-date stamp	DW Powers Consultant to WTS
SNL-2_Core188.jpg	5-29-03	SNL-2 drillpad; T22S, R30E, Sec12	Close-up photo of Salado Fm core, 593.0 – 594.1 ft bgl, with markings, scale and time-date stamp	DW Powers Consultant to WTS
SNL-2_Core189.jpg	5-29-03	SNL-2 drillpad; T22S, R30E, Sec12	Close-up photo of Salado Fm core, 594.0 – 595.2 ft bgl, with markings, scale and time-date stamp	DW Powers Consultant to WTS
SNL-2_Core190.jpg	5-29-03	SNL-2 drillpad; T22S, R30E, Sec12	Close-up photo of Salado Fm core, 594.9 – 596.0 ft bgl, with markings, scale and time-date stamp	DW Powers Consultant to WTS
SNL-2_Core191.jpg	5-29-03	SNL-2 drillpad; T22S, R30E, Sec12	Close-up photo of Salado Fm core, 596.0 – 597.1 ft bgl, with markings, scale and time-date stamp	DW Powers Consultant to WTS
SNL-2_Core192.jpg	5-29-03	SNL-2 drillpad; T22S, R30E, Sec12	Close-up photo of Salado Fm core, 597.1 – 598.3 ft bgl, with markings, scale and time-date stamp	DW Powers Consultant to WTS
SNL-2_Core193.jpg	5-29-03	SNL-2 drillpad; T22S, R30E, Sec12	Close-up photo of Salado Fm core, 598.3 – 599.2 ft bgl, with markings, scale and time-date stamp	DW Powers Consultant to WTS
SNL-2_Core194.jpg	5-29-03	SNL-2 drillpad; T22S, R30E, Sec12	Close-up photo of Salado Fm core, 598.8 – 600.2 ft bgl, with markings, scale and time-date stamp	DW Powers Consultant to WTS

Photograph Log Sheet

FILE	DATE	LOCATION	DESCRIPTION OF SUBJECT (includes individual / group names, direction, etc., as appropriate)	PHOTOGRAPHER (initials and dept.)
SNL-2_Core195.jpg	5-29-03	SNL-2 drillpad; T22S, R30E, Sec12	Close-up photo of Salado Fm core, 599.8 – 601.3 ft bgl, with markings, scale and time-date stamp	DW Powers Consultant to WTS
SNL-2_Core196.jpg	5-29-03	SNL-2 drillpad; T22S, R30E, Sec12	Close-up photo of Salado Fm core, 600.8 – 602.2 ft bgl, with markings, scale and time-date stamp	DW Powers Consultant to WTS
SNL-2_Core197.jpg	5-06-03	SNL-2 drillpad; T22S, R30E, Sec12	Close-up photo of Salado Fm core, 601.8 – 603.3 ft bgl, with markings, scale and time-date stamp	DW Powers Consultant to WTS
SNL-2_Core198.jpg	5-06-03	SNL-2 drillpad; T22S, R30E, Sec12	Close-up photo of Salado Fm core, 602.9 – 604.3 ft bgl, with markings, scale and time-date stamp	DW Powers Consultant to WTS
SNL-2_Core199.jpg	5-06-03	SNL-2 drillpad; T22S, R30E, Sec12	Close-up photo of Salado Fm core, 603.8 – 605.2 ft bgl, with markings, scale and time-date stamp	DW Powers Consultant to WTS
SNL-2_Core200.jpg	5-06-03	SNL-2 drillpad; T22S, R30E, Sec12	Close-up photo of Salado Fm core, 604.7 – 606.2 ft bgl, with markings, scale and time-date stamp	DW Powers Consultant to WTS
SNL-2_Core201.jpg	5-06-03	SNL-2 drillpad; T22S, R30E, Sec12	Close-up photo of Salado Fm core, 604.8 – 606.3 ft bgl, with markings, scale and time-date stamp	DW Powers Consultant to WTS
SNL-2_Core202.jpg	5-06-03	SNL-2 drillpad; T22S, R30E, Sec12	Close-up photo of Salado Fm core, 605.7 – 607.2 ft bgl, with markings, scale and time-date stamp	DW Powers Consultant to WTS
SNL-2_Core203.jpg	5-06-03	SNL-2 drillpad; T22S, R30E, Sec12	Close-up photo of Salado Fm core, 607.9 – 609.3 ft bgl, with markings, scale and time-date stamp	DW Powers Consultant to WTS
SNL-2_Core204.jpg	5-06-03	SNL-2 drillpad; T22S, R30E, Sec12	Close-up photo of Salado Fm core, 608.8 – 610.2 ft bgl, with markings, scale and time-date stamp	DW Powers Consultant to WTS
SNL-2_Core205.jpg	5-06-03	SNL-2 drillpad; T22S, R30E, Sec12	Close-up photo of Salado Fm core, 609.8 – 611.4 ft bgl, with markings, scale and time-date stamp	DW Powers Consultant to WTS
SNL-2_Core206.jpg	5-06-03	SNL-2 drillpad; T22S, R30E, Sec12	Close-up photo of Salado Fm core, 610.7 – 612.3 ft bgl, with markings, scale and time-date stamp	DW Powers Consultant to WTS
SNL-2_Core207.jpg	5-06-03	SNL-2 drillpad; T22S, R30E, Sec12	Close-up photo of Salado Fm core, 611.7 – 613.3 ft bgl, with markings, scale and time-date stamp	DW Powers Consultant to WTS
SNL-2_Core208.jpg	5-06-03	SNL-2 drillpad; T22S, R30E, Sec12	Close-up photo of Salado Fm core, 612.7 – 614.0 ft bgl, with markings, scale and time-date stamp	DW Powers Consultant to WTS

Camera: Casio QV-3500EX **Resolution**: 2048 x 1536 **Page 14 of 14**

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