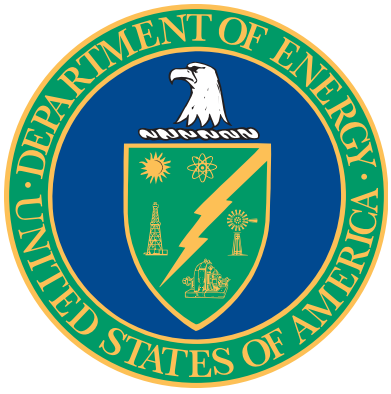
DOE/WIPP-07-3364

Basic Data Report
For Drillhole SNL-16 (C-3220)
(Waste Isolation Pilot Plant)

February 2009



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DOE/WIPP-07-3364

Basic Data Report
For Drillhole SNL-16 (C-3220)
(Waste Isolation Pilot Plant)

Dennis W. Powers
Consulting Geologist
140 Hemley Road
Anthony, TX 79821

February 2009

West Texas Water Well Service Rig #15 at SNL-16 on April 12, 2006. Toward north-northwest, with Livingston Ridge in background behind Nash Draw mine headframes. Taken by Dennis W. Powers.

EXECUTIVE SUMMARY

SNL-16 (permitted by the New Mexico State Engineer as C-3220) was drilled and completed during April 2006 to provide geological data and hydrological testing of the Culebra Dolomite Member of the Permian Rustler Formation in the southeastern arm of Nash Draw and west-southwest of the Waste Isolation Pilot Plant (WIPP) site. SNL-16 is in the area where upper Salado Formation halite has been dissolved and is in the mudflat facies tract of Rustler mudstone-halite units. Culebra transmissivity is expected to be relatively high. SNL-16 is located in the southeast quarter of section 33, T22S, R30E, in eastern Eddy County, New Mexico. SNL-16 was drilled to a total depth (TD) of 299.3 feet (ft) below ground level (bgl), based on driller's measurements. Below the caliche pad, SNL-16 encountered the Mescalero caliche, Gatuña, and Rustler Formations. The Santa Rosa, Dewey Lake, and uppermost Rustler Formations have been eroded at SNL-16. Two intervals of the Rustler were cored: 1) from the lower Forty-niner Member through lower Magenta Dolomite Member and 2) from M-3 of the Tamarisk Member through the Culebra Dolomite and through most of the Los Medaños Member. Geophysical logs were acquired from the open hole to a depth of ~285 ft. Water was encountered in A-3 of the Tamarisk Member as well as the Culebra; coring continued with mist and soap to TD.

Lower Los Medaños core recovery was very limited and of little use in determining the stratigraphic position at TD. It is inferred as likely to be near the base of the Rustler. The upper part of the Los Medaños has more normal lithology, thickness, and stratigraphic sequence for areas west of WIPP. The upper part of the lower mudstone-halite unit (M-1/H-1) of the Los Medaños includes clasts and some fracturing that may be due to subsidence after dissolution of upper Salado halite. A silty claystone with siltstone clasts underlies Anhydrite 1 (A-1). A-1 is mainly laminated to bedded gypsum with some fracturing near the top and disruption of the upper surface. This is attributed mainly to exposure prior to deposition of overlying M-2. The upper clastic-halite unit of the Los Medaños (M-2/H-2) at SNL-16 was partially recovered in cores, and it is represented only by mudstone facies (M-2). The contact with the overlying Culebra was recovered. The uppermost core from M-2 is laminated gray silty claystone, and the laminae are horizontal deeper and deformed at the Culebra contact, as are basal laminae of the Culebra. This limited deformation is consistent with limited soft deformation as the Culebra was being deposited rather than removal of halite from the M-2/H-2 interval and subsidence.

Core recovery from the Culebra was variable, with most of the lower middle not recovered. No gypsum was observed from recovered Culebra core. The upper part of the Culebra was more completely recovered, revealing bedding and some laminae with few vugs. There are subvertical fractures within the core, and some are stained. Fracturing near the middle appears to have collapsed vuggy porosity. Collapsed vuggy porosity in the lower middle Culebra may have caused the lack of core recovery. There are some concentrated laminae in the more organic-rich zone in the upper 1 ft. The Culebra is 24 ft thick as measured by geophysical logs. This is in the lower range of normal for the WIPP site. Given the fracturing and collapse, the Culebra is expected to show relatively high transmissivity.

The Tamarisk has a normal stratigraphic sequence for the area west of the H-3 margin, but unit thicknesses differ from the immediate WIPP site area. The basal sulfate (A-2) is mainly gray gypsum that displays horizontal beds and laminae. It is only 7 ft thick in logs. The upper half has been corroded or eroded; disruptions to beds indicate most has been removed by more recent dissolution. A laminated siltstone and

claystone that persists across the WIPP area is not identifiable. Internal corrosion surfaces and reddish brown siltstone indicate solution and infiltration. Coarse gypsum fills some fractures. At SNL-16, mudstone (M-3) of the Tamarisk shows sulfate and siltstone clasts in reddish brown matrix with no upward sorting evident. Logs indicate 16 ft of M-3, which is a thickness consistent with the WIPP site area. The upper Tamarisk sulfate (A-3) is 92 ft thick, as measured by geophysical logging, and this is ~30 ft thicker than in the WIPP site area. Cuttings indicate both finer gray gypsum and coarse clear gypsum. A-3 has likely been thickened by subsidence and collapse associated with dissolution. Downhole video shows a high-angle fracture and water flow in A-3 at 97–95 ft. Facies tract analysis indicates SNL-16 is well beyond the expected limits of H-3 deposition, and the lengthened A-3 section is consistent with more recent dissolution of upper Salado halite as well as some dissolution and collapse within A-3.

The Magenta Dolomite is 32 ft thick in logs, which is above normal for the member but within the regional range. The core displays normal thin bedding and laminae ranging from wavy to cross- and ripple-bedded to horizontal. The basal zone that normally shows evidence of stromatolite forms elsewhere was not cored. Small nodules occur below the top of the Magenta. Most of the bedding within the Magenta is near-horizontal and does not indicate tilting of the section. Fractures are present, and gypsum fills some apertures. The zone that is more typically porous in the upper middle part of the Magenta in many Magenta cores across the site area was not identified at SNL-16. The fracturing likely makes the Magenta relatively transmissive, but no water inflow was observed.

The Forty-niner is represented only by the lower sulfate bed. The upper sulfate and middle mudstone units have been eroded. The basal gypsum (A-4) is 5.9 ft thick. The core shows gypsum as well as interbedded siltstone near the top. Some possible small gypsum growth textures are present. Stylolites have also formed along bedding planes.

The Gatuña at SNL-16 is a 27-ft thick reddish brown siltstone and sandstone. The lowest dark reddish brown siltstone (~1 ft thick) includes gypsum veins, overlies A-4, and is disturbed or redeposited mudstone from M-4. Magenta clasts were recovered from the basal Gatuña, in the uppermost core from SNL-16. Cuttings at shallower depth included small chert granules or pebbles.

The Mescalero caliche is sandy limestone, approximately 4 ft thick, at SNL-16, and cuttings were insufficient to determine the stage of development as a pedogenic calcrete.

The sand above the Mescalero is reddish, rounded, and slightly lithified.

SNL-16 was drilled (and reamed through cored intervals) with an original diameter of 11 inches to 228 ft for completion. Fiberglass reinforced plastic (FRP) casing (4.85 inches inside diameter) was placed in the hole, with a screen interval across the Culebra Dolomite from 216.0–189.85 ft below the top of the connector on the conductor casing. Blank casing with an endcap was added to bring the bottom of the casing to 224 ft. Approximately 2.5 ft of FRP casing was left above the connector. After coring to TD of 299.3 ft, logging showed open hole to ~287 ft, with log data from ~285 ft. The cored interval was cemented up to 239 ft and HolePlug® (bentonite) was added up to 232 ft. The annulus was filled with 4/10 gravel to 187 ft, above the Culebra. HolePlug® was placed from 187–182 ft to separate the Culebra from the Tamarisk mudstone. The annulus above the bentonite was cemented to the surface.

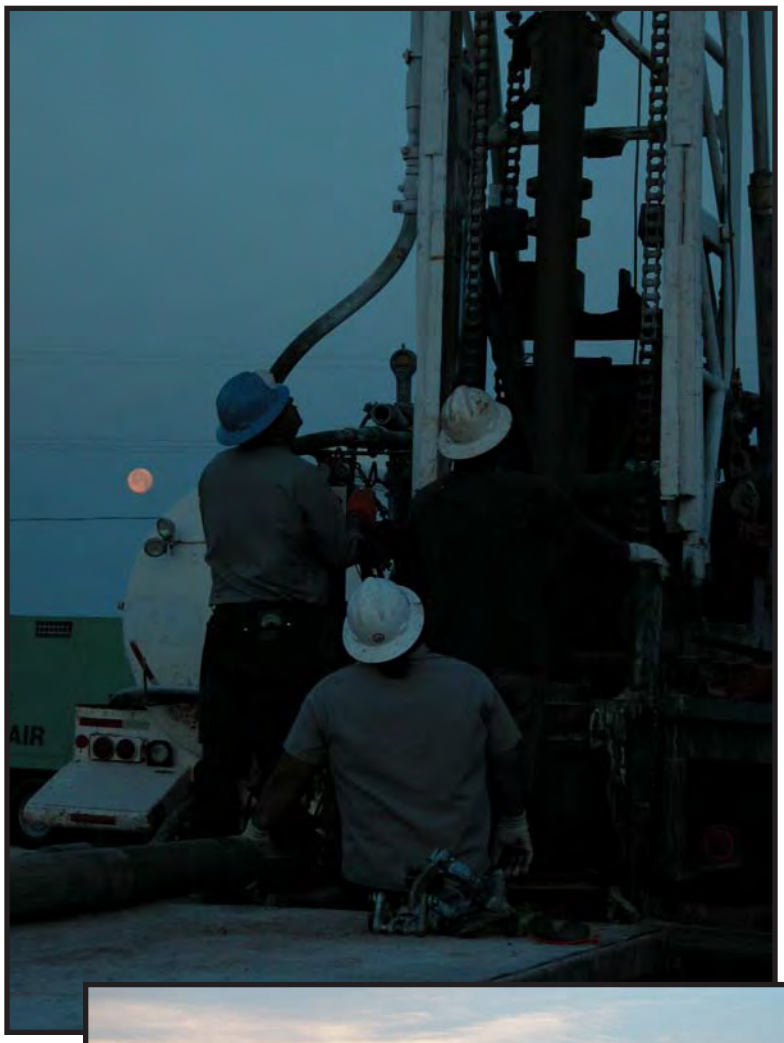
SNL-16 was completed April 19, 2006. The first water level recorded by Washington Regulatory and Environmental Services (WRES) was measured September 12, 2006; the initial depth to water was 121.10 ft below the top of casing.

Table of Contents

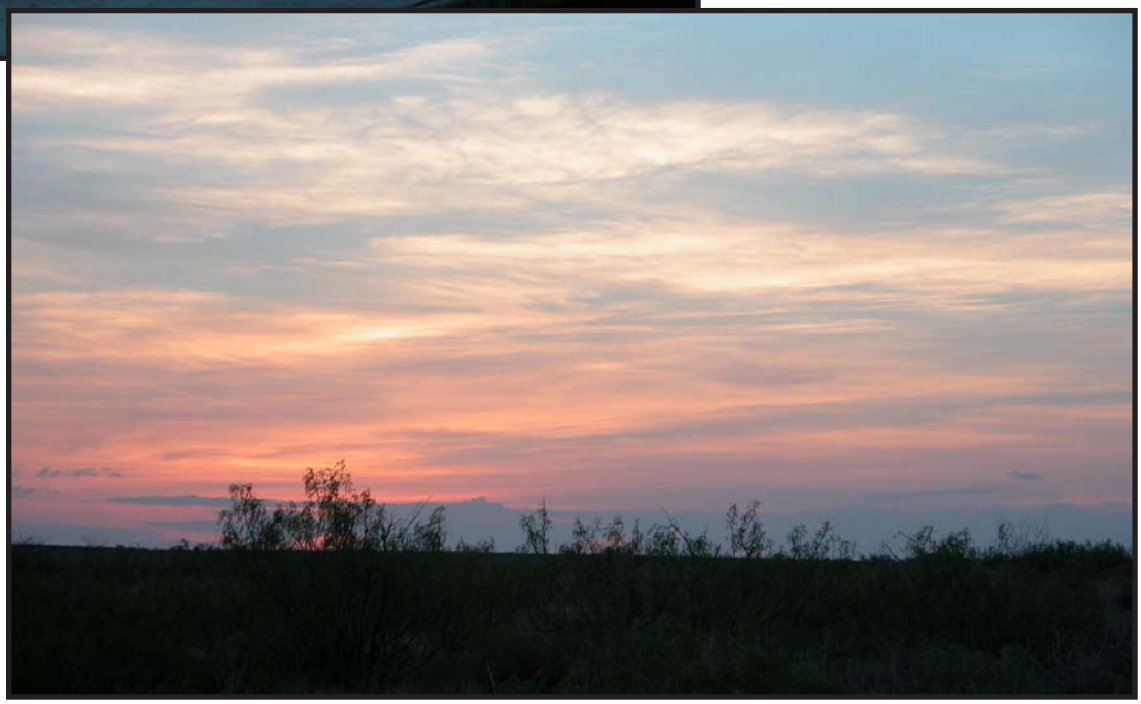
List of Figures and Tables

In keeping with practice at the WIPP site, the basic data for SNL-16 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)



Early morning, April 14, 2006 at SNL-16. Photos by Dennis W. Powers
(left - to southwest)
(below - to east)



1.0 INTRODUCTION

SNL-16 was drilled in the southeast quarter of section 33, T22S, R30E, in eastern Eddy County, NM (Fig. 1-1). It is located 1,220 ft from the south line (fsl) and 1,565 ft from the east line (fel) of the section (Fig. 1-2). This location places the drillhole in the southeastern arm of Nash Draw, west of the WIPP site. SNL-16 was begun on April 10, 2006, and was completed April 19. SNL-16 will be used to monitor groundwater levels of the Culebra Dolomite Member of the Permian Rustler Formation for WIPP in an area of expected high transmissivity and possible recharge.

SNL-16 was permitted by the NM State Engineer as C-3220. Official correspondence regarding permitting and regulatory information must reference this permit number.

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

1.1 Purpose of WIPP

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

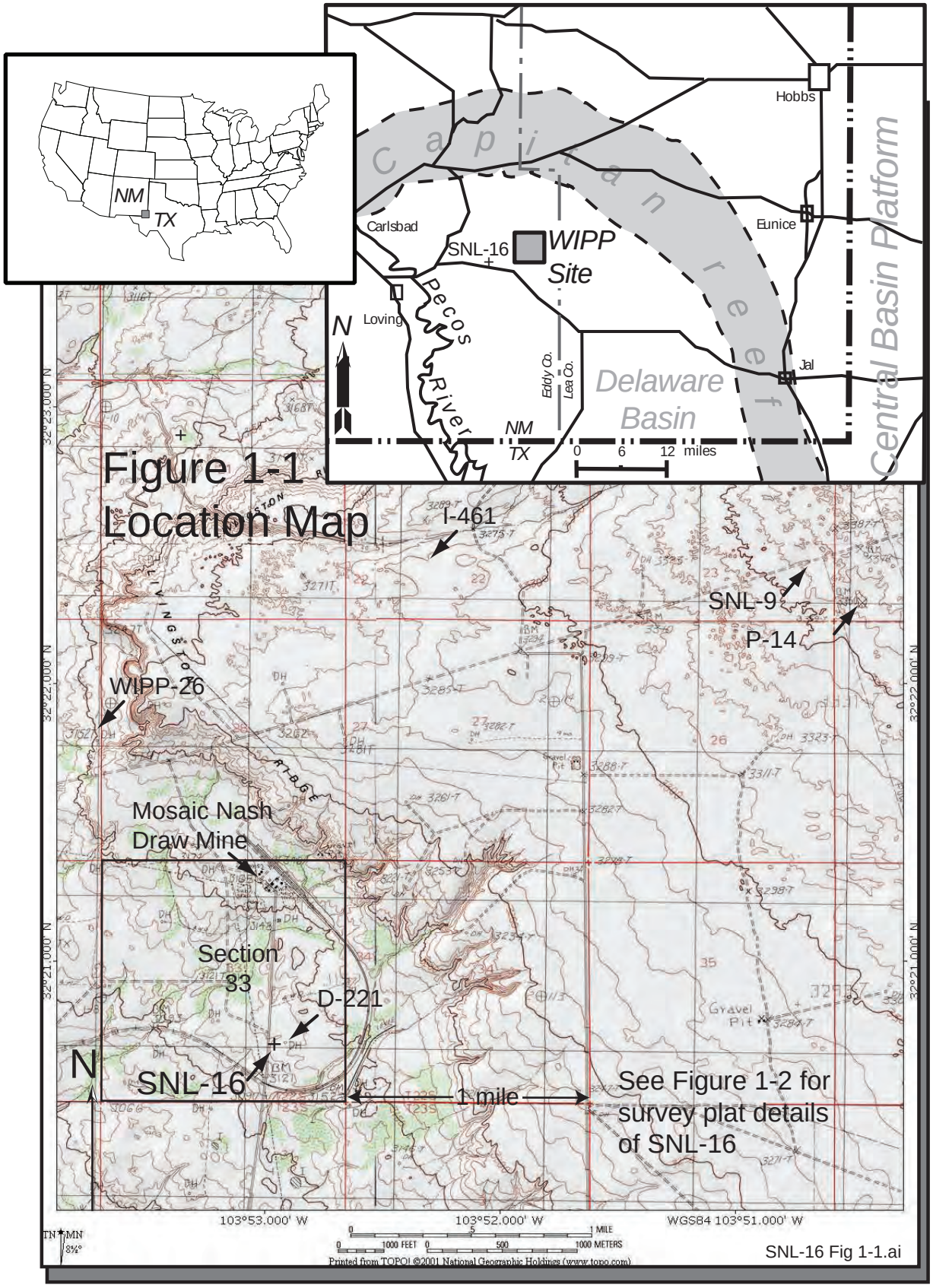
1.2 Purpose of SNL-16

SNL-16 was designed and located to provide information for the integrated hydrology program for WIPP (Sandia National Laboratories [SNL], 2003). SNL-16 also was located in part to be a replacement for WIPP-26, which was subsequently plugged and abandoned (U.S. DOE, 2007). Among the objectives of the integrated hydrology program, SNL-16 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 …" (SNL, 2003, p. 1).

Culebra water levels in many of the wells monitored for WIPP have been rising in recent years, contrasting with the conditions used to calibrate models of the Culebra across the site area (SNL, 2003) for the Compliance Certification Application (CCA; U.S. DOE, 1996). Hydraulic properties of the Culebra vary spatially, and three factors (overburden, upper Salado dissolution, and Rustler halite distribution) appear to explain most of the variability in transmissivity (Holt and Yarbrough, 2002; Holt and others, 2005; Holt and Powers, 2002; Powers and others, 2003). The Compliance Recertification Application (CRA; U.S. DOE, 2004) submitted to the EPA models release scenarios through the Culebra using transmissivity fields based on these factors.

SNL-16 was located west of the WIPP site in Nash Draw, where Culebra transmissivity is expected to be relatively high and where recharge may be occurring (Appendix A; see SNL, 2003, for general information). Geologic data would help delineate shallow stratigraphy. SNL-16 provided a location for (Appendix A):

1. Testing confinement of the Culebra near the upper Salado dissolution margin;
2. Testing the relationship between potential surface recharge events and Culebra hydraulic events in a karsted drainage basin,


NM
TX
Hobbs
Carlsbad
Eunice
SNL-16
WIPP Site
Loving
Pecos River
Jal
Eddy Co.
Lea Co.
Delaware Basin
Central Basin Platform
Capitan reef
N
0 6 12 miles
NM
TX
Figure 1-1
Location Map
I-461
SNL-9
P-14
WIPP-26
Mosaic Nash Draw Mine
Section 33
D-221
SNL-16
1 mile
See Figure 1-2 for survey plat details of SNL-16
103°53.000' W
103°52.000' W
WGS84 103°51.000' W
32°23.000' N
32°22.000' N
32°21.000' N
Printed from TOPO! ©2001 National Geographic Holdings (www.topo.com)
SNL-16 Fig 1-1.ai

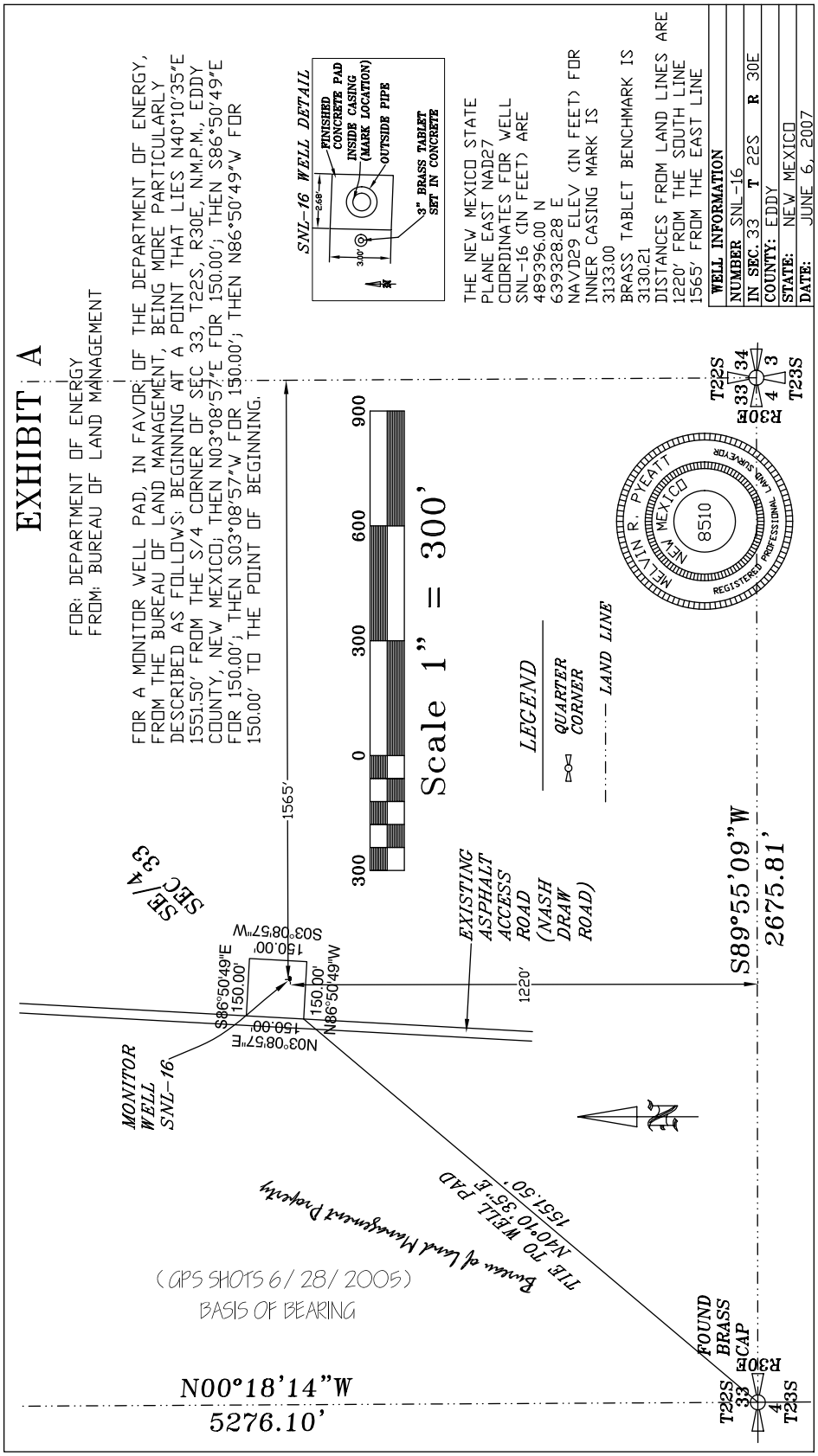


Figure 1-2
Survey Plat
for SNL-16

3. Obtaining detailed stratigraphic data on shallow units; and
4. Providing a general replacement for WIPP-26 in a strategic location to monitor hydraulic behavior along the southwestern area of the model domain.

1.3 SNL-16 Drilling and Completion

The basic information about drilling and completion of SNL-16 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-16 was rotary drilled and cored to a TD of 299.3 ft bgl (Fig. 1-3) as measured during drilling. Core recovery was poor to complete in different runs (Table 1-1). The last recovered material may or may not represent this depth. Geophysical logging indicated that the drillhole was open to ~287 ft, with log data obtained from ~285 ft. The bottom of SNL-16 was plugged back with cement to ~239 ft, and HolePlug® was added to bring the depth to 232 ft before reaming the cored interval to 228 ft. SNL-16 was drilled to 123 ft using compressed air only; compressed air with mist was used to complete drilling and coring. Cuttings from SNL-16 were of useful size because of these methods.

Core recovery was variable, with the average recovery ~65% (Table 1-1; Appendix C). The lower middle Culebra showed poor recovery, and this is consistent with many other cored locations. Complete core recovery is rare through the Culebra (e.g., Powers, 2002b; Mercer and others, 1998).

In keeping with recent practice at WIPP, SNL-16 was cased with FRP casing rather than steel to provide longer utility of the well for monitoring and testing. Steel-cased wells at WIPP are expected to be plugged and abandoned and, where necessary, replaced with wells completed with FRP casing (SNL, 2003).

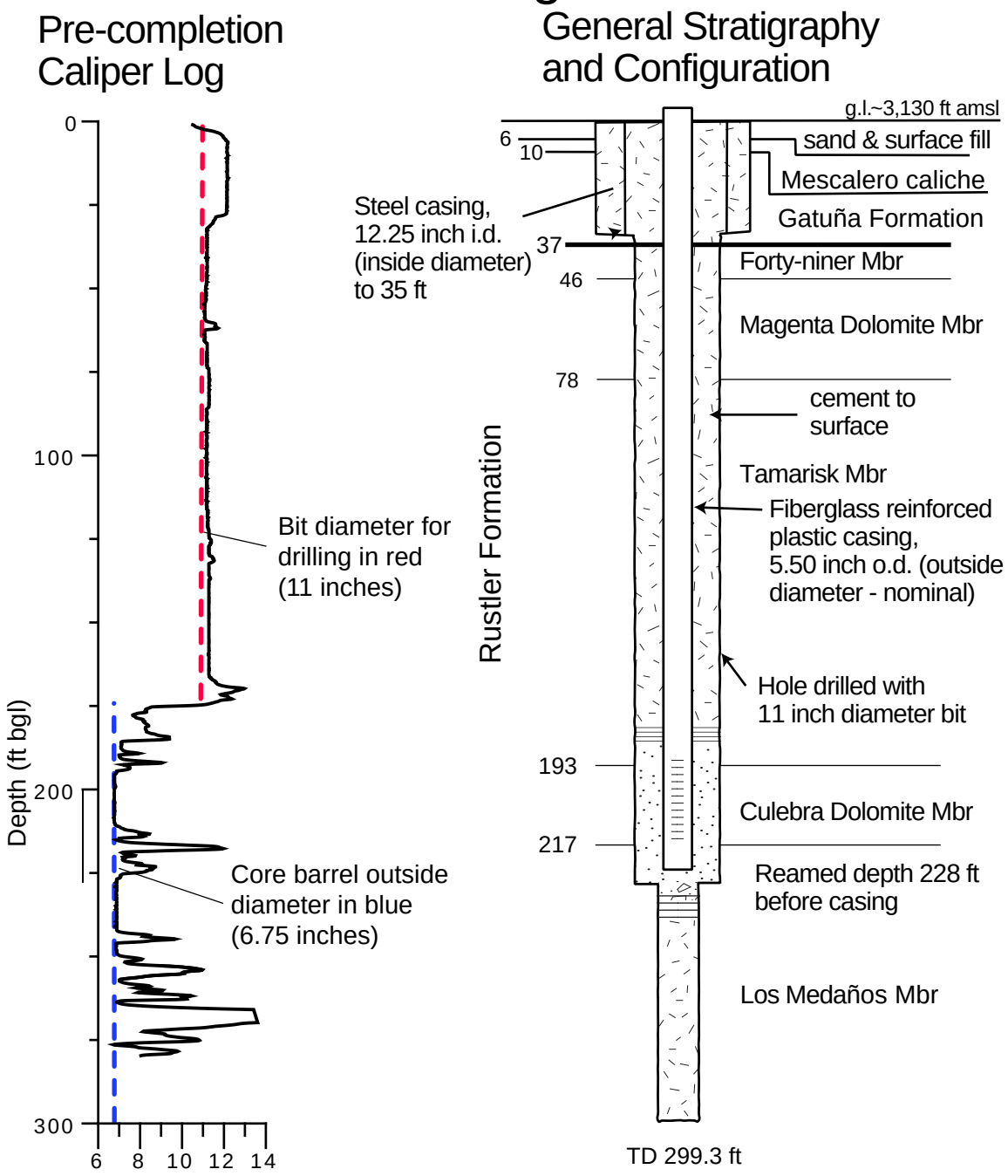
SNL-16 was completed with a single screened interval for monitoring and testing of only the Culebra Dolomite (Fig. 1-4). With a single completion interval, some of the difficulties associated with multiple completions can be avoided: expense of buying, placing, and maintaining packers; loss of water-level 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. No wells to other intervals have been proposed for the SNL-16 wellpad.

Geophysical logs, especially the natural gamma and caliper logs, were used to make the final decisions regarding completion of SNL-16 (Fig. 1-4) (Appendices D and E). The drillhole penetrated most of the lower Rustler, and cement and HolePlug® was put into SNL-16 to prevent circulation into that interval (Fig. 1-4). The bottom of the Culebra screen interval was placed at 216.0 ft, just above the base of the Culebra and underlying claystone. The top of the screen, at 189.85 ft, is above the top of the Culebra. The top of the gravel pack (4/10 silica gravel) at 187 ft is below the mudstone in the Tamarisk to prevent connection to the Culebra. Bentonite (HolePlug®) was placed to 182 ft, and the annulus above the bentonite was cemented to the surface. The caliper log (Fig. 1-3) before the drillhole was reamed to 228 ft at a diameter of 11 inches and before the casing was placed shows drillhole enlargement in the Tamarisk mudstone and lower intervals.

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

A steel surface conductor casing was cemented in place to a depth of 35 ft bgl, with the top of the cutoff conductor casing ~6 inches above the pad level (Fig. 1-5) serving as a common reference point for drilling; geophysical logging; and placing the screened interval, sand pack, bentonite seal, and cement. The top of the steel connector was estimated to have an elevation of 3,129 ft amsl (above mean sea level), based on a pre-drilling

Figure 1-3
SNL-16 As-Built Diagram



SNL-16 Diameter (inches)
(after drilling to 11 inches to 174 ft
and coring to 299.3 ft)
See Figures 1-4 and 1-5 for
additional details

Note: Depths for drilling, geophysical logs, and completion are referenced to the top of the steel connector on the surface conductor casing, which is at the surface of the drilling pad at SNL-16 and is taken as 3,130 ft amsl.

Table 1-1. Summary of Drilling and Well Completion Records for Hydrologic Drillhole SNL-16 (C-3220)

LOCATION: Southeast ¼, Section 33, Township 22 South (T22S), Range 30 East (R30E)

SURFACE COORDINATES: The well is located 1,220 ft from the south line (fsl) and 1,565 ft from the east line (fel) of Section 33. The New Mexico State Plane (NAD 27) horizontal coordinates in feet are 489396.00 North, 639328.28 East (Fig. 1-2 shows the survey plat). Universal Transverse Mercator (UTM) horizontal coordinates (NAD27, Zone 13) in meters were calculated for SNL-16 using Corpscon for Windows (v. 6): 605191.79 East, 3578999.71 North. Figure 1-1 shows 1,000-m UTM gridlines.

ELEVATION: All depths from geological and geophysical data used for completion were measured from the surface conductor casing just above the level of the drillpad surface (Fig. 1-5). Depths are reported as bgl, which is taken as 3,130 ft above mean sea level (amsl), the rounded value for the brass tablet benchmark (3,130.21 ft amsl) adjacent to the cement well pad. The primary datum for the completed well is 3,133.00 ft amsl (NGVD 29) for a mark on the fiberglass reinforced plastic casing inside the protective well pipe. Figures 1-3, 1-4, and 1-5 show the as-built configuration of SNL-16.

DRILLING RECORD:

Dates: Began drilling April 10, 2006; drillhole reached TD (299.3 ft) on April 17, 2006. Geophysical logging was conducted on April 18, 2006, and the lowermost part of the cored interval was cemented April 18. Drillhole was reamed to 228 ft on April 19. SNL-16 was cased and cemented April 19, 2006. SNL-16 was jetted on April 25 using 100 barrels of potable water from Eunice, NM; there were no returns to surface. SNL-16 was developed by pumping on April 26, 2006.

Circulation Fluid: SNL-16 was drilled and cored to 123 ft bgl with circulating air. Moist cuttings and inflow at 123 ft resulted in using additional fresh water and Quik-Foam® to drill from 123 ft to TD, discharging cuttings into a lined portable steel container.

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

35.0–73.0 ft bgl: basal Forty-niner and Magenta Dolomite Members
174.0–299.3 ft bgl: lower Tamarisk, Culebra Dolomite, and Los Medaños Members

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

Table 1-1. Summary of Drilling and Well Completion Records for Hydrologic Drillhole SNL-16 (C-3220), continued

Drillhole Record:

Size (inches)	From (ft bgl)	To (ft bgl)
17.5	0	35
11	35	228
6.75	228	299.3

Casing Record:

Outside diameter (inches)	Inside diameter (inches)	Weight/ft (pounds)	From (ft bgl)*	To (ft bgl)
12.75	12.25	48 steel	-3	35
5.45	4.85	3.20 FRP** blank	-2.5	189.85
5.45	4.85	3.20 FRP screen	189.85	216.0
5.45	4.85	3.20 FRP blank	216.0	224.0

*Top of the casing connector is the reference for depth denoted bgl. The FRP extends approximately 2.5 ft (-2.5) above the steel casing connector.
**FRP: fiberglass reinforced plastic
Principal supplier and size: Centron® 5 1/2 DHC .300

Coring Record:

Core Run No.	Depth Interval (ft) From	To	Interval (ft) Cored	Recovered	Recovered %
1	35	46.5	11.5	10.5	91.30%
2	46.5	73	26.5	26.5	100.00%
3	174	185	11	8.6	78.18%
4	185	197.3	12.3	11	89.43%
5	197.3	203.8	6.5	6.5	100.00%
6	203.8	213.8	10	2.6	26.00%
7	213.8	224.3	10.5	6	57.14%
8	224.3	254.3	30	28.6	95.33%
9	254.3	284.3	30	6	20.00%
10	284.3	299.3	15	0.5	3.33%
		Totals	163.3	106.8	65.40%

Figure 1-4
SNL-16 Completion and Monitoring Configuration (4/19/06)

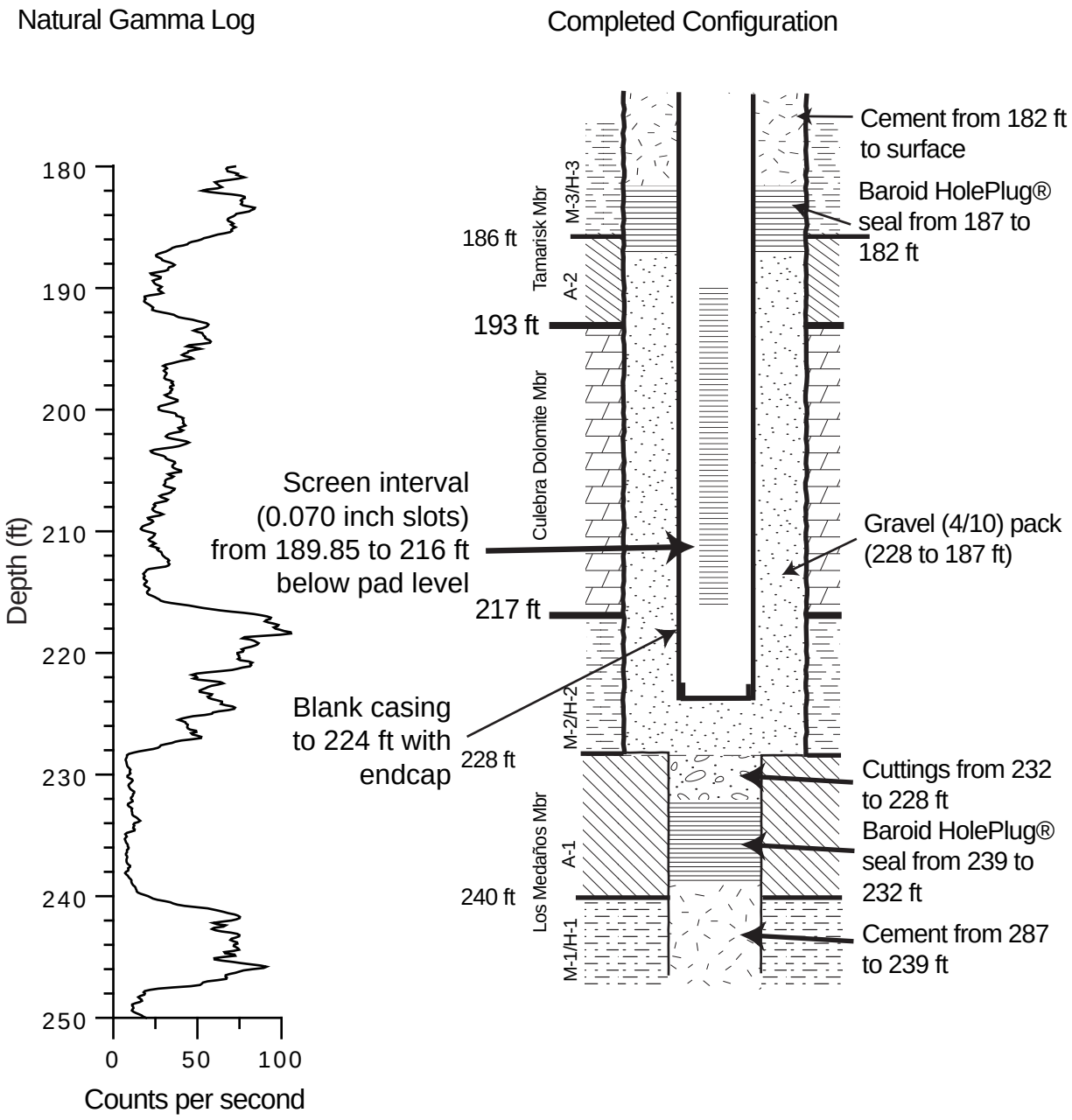
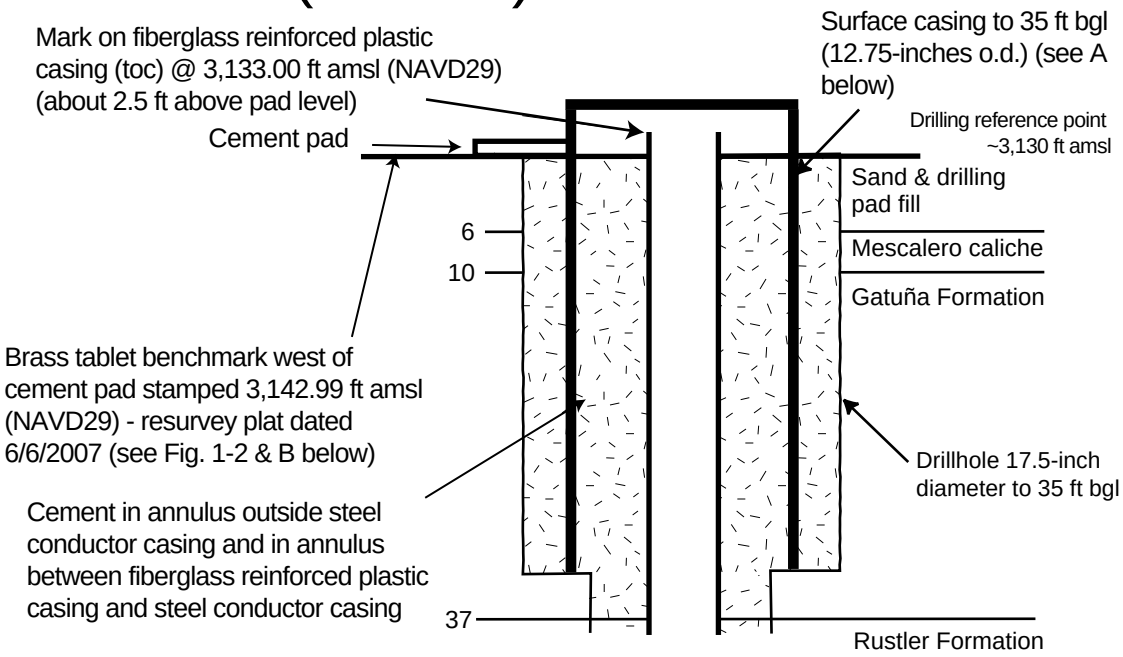
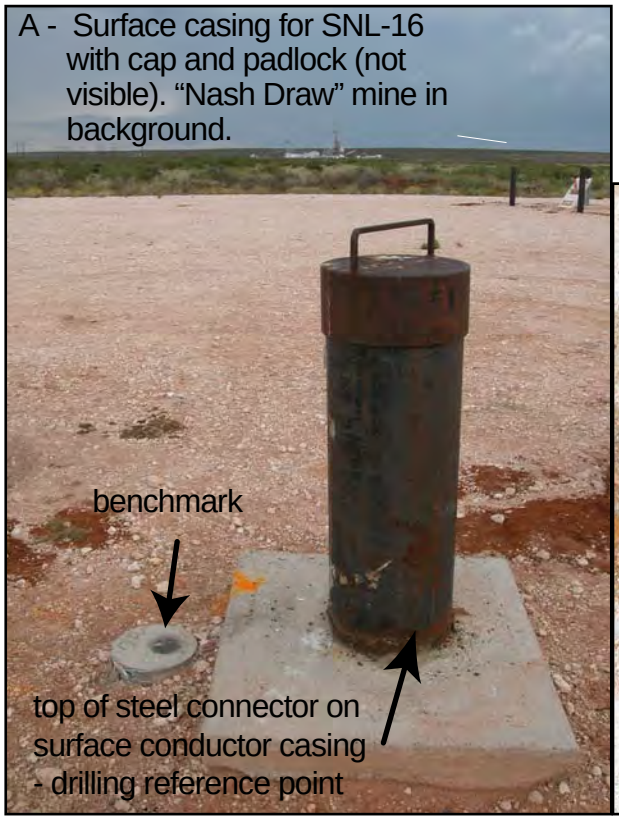


Figure 1-5
SNL-16 Surface Configuration and Elevation (9/20/07)

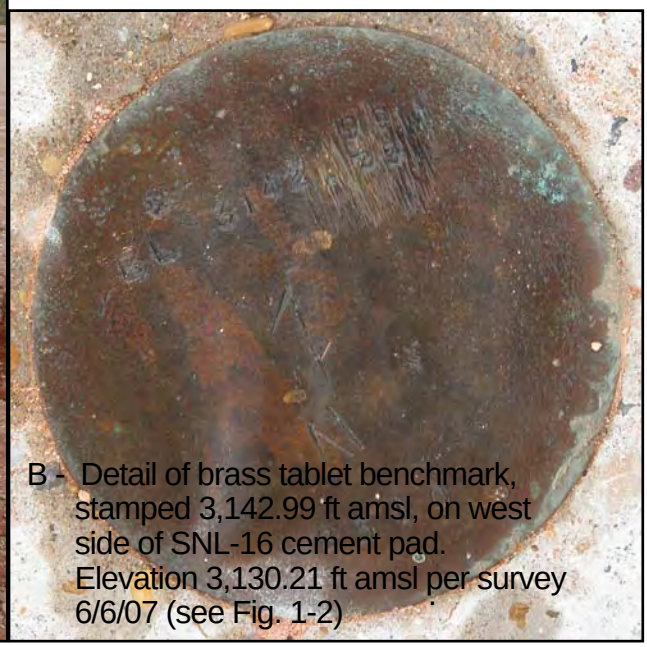


Note: Drawing is not to scale.



A - Surface casing for SNL-16 with cap and padlock (not visible). "Nash Draw" mine in background.

Photos by Dennis W. Powers 9/20/07



B - Detail of brass tablet benchmark, stamped 3,142.99 ft amsl, on west side of SNL-16 cement pad. Elevation 3,130.21 ft amsl per survey 6/6/07 (see Fig. 1-2)

survey of the well pad. The benchmark placed at the drilling pad surface next to the completed well has an elevation of 3,130.20 ft amsl (survey plat dated June 6, 2007) and is very close to the elevation of the connector on the casing. The original stamped value on the benchmark was 3,142.99 ft amsl, and the benchmark has not been remarked. *Other than water-level monitoring, depths are stated as bgl, and the top of the steel connector on the surface conductor casing is taken as a proxy reference point for ground level with an elevation of ~3,130 ft amsl (Figs. 1-3, 1-4, and 1-5).* The FRP casing projects ~2.5 ft above the steel connector on top of the conductor casing. This FRP casing point is surveyed (Fig. 1-5), and it provides the reference point and reference elevation (3,133.00 ft amsl) for monitoring water levels.

1.4 Other Background

SNL-16 was drilled and completed by the West Texas Water Well Service, 3410 Mankins, Odessa, TX, under contract from Washington TRU Solutions LLC (WTS). Coring was done by John Wood, Diamond Oil Well Drilling Co., Inc., P.O. Box 7843, Midland, TX. Geophysical logging was conducted by Al Henderson, Jet West Geophysical Services, LLC, 2550 La Plata Highway, Farmington, NM, 87499-3522, under contract to West Texas Water Well Service. Geological support was provided by Dennis W. Powers under contract to WTS. Well drilling wastes (cuttings) were removed from SNL-16 and disposed of at the Lea Land, Inc., landfill north of WIPP. Archeological clearances obtained from the U.S. Bureau of Land Management were based on field work and reports by Mesa Field Services, Carlsbad, NM (Appendix E). Cores from SNL-16 were photographed with a digital camera, and a photo log is included in Appendix F. Electronic images can be requested from WTS.

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

1.5 Acknowledgements

Drafts of this document were reviewed by Rick Salness, Joel Siegel, Tricia Johnson, and Rick Beauheim, and their comments improved the final report. Ron Richardson (Washington Regulatory and Environmental Services - WRES) provided field support during drilling. Mark Crawley (WRES) provided field support and information on well development. Larry Keith and Luis Armendariz (West Texas Water Well Service) provided drilling data and daily drilling records. West Texas Water Well Service personnel were very helpful in providing access for sampling during drilling. Al Henderson (Jet West Geophysical Services) provided the printed and electronic files that were used to develop Figure 2-1. Vivian Allen (L&M) provided useful editorial guidance and management of the review process.

2.0 GEOLOGICAL DATA

2.1 General Geological Background

The geology and hydrology of formations at the WIPP site and surroundings have been intensively investigated since 1975, and the information and interpretations have been reported in numerous documents. The most thorough compilation is certainly the Compliance Certification Application (CCA) submitted in 1996 by the DOE to the EPA (U.S. DOE, 1996). Some salient features of the broader geological history, as well as more recent work on the geohydrology of the Rustler (e.g., Holt and Yarbrough, 2002; Powers, 2002a, 2003; Powers and others, 2003), are relevant to understanding the geology and hydrology at SNL-16.

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

2.2 Geological Data From SNL-16

SNL-16 encountered a truncated stratigraphic sequence from ground level to total depth, and this is anticipated for this location in the southeastern arm of Nash Draw (Fig. 2-1; Table 2-1). Units encountered ranged from unconsolidated surface sand to the poorly consolidated (unrecovered) lower Los Medaños Member of the Permian Rustler Formation. Structural, sedimentological, and diagenetic features were examined during investigation using cuttings, cores, and geophysical logs. Details of the sedimentology of the Rustler will extend understanding of that unit. Moist cuttings were encountered while drilling the upper Tamarisk, and drilling and coring were modified to use mist.

The geologic units encountered in SNL-16 are described from TD 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 log and drilling depth is generally slight. Decisions about placing screen intervals and annulus fillings were based on depths indicated by geophysical logs (Appendix G).

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

2.2.1 Permian Rustler Formation

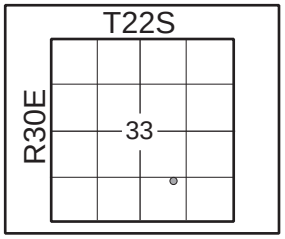
The Rustler was drilled and cored into the upper Los Medaños Member. The contact between the Rustler and the overlying Gatuña Formation is at 37 ft (Fig. 2-2; Table 2-1), and 262.3 ft of the Rustler were penetrated at SNL-16 (Table 2-1).

2.2.1.1 Los Medaños Member

The Los Medaños was named by Powers and Holt (1999) based on the rocks described in shafts at the WIPP site. For the area around WIPP,

Figure 2-1
Well Record SNL-16 (C-3220)

Company: Washington TRU Solutions LLC
Well: SNL-16 (C-3220)
Section: 33 Twp: T22S Rge: R30E
Location: 1,220 ft from south line (fsl)
1,565 ft from east line (fel)



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

Elevation
KB:
DF:
GL: 3,130 ft amsl
(benchmark: 3,130.21)

Drilling contractor: West Texas Well Water Service
Coring contractor: Diamond Oil Well Drilling Co.
Geophysical logs: Al Henderson
Jet West Geophysical Services, LLC (NM)
Geologist: Dennis W. Powers
Spud date: April 10, 2006
Completion date: April 19, 2006
Total depth (TD): 299.3 ft bgl (driller log)

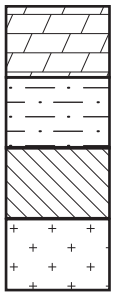
Casing Record
Conductor: 35 ft
12.75 inch o.d. steel
Casing: 5.45 inch o.d.
fiberglass reinforced
plastic to 226.5 ft bgl
Screened interval:
216.00-189.85 ft bgl

Geophysical Logs Date: April 18, 2006

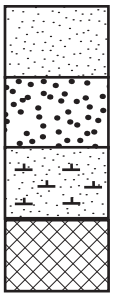
Micro/Laterolog/SP:	125-282 ft
Gamma	0-285 ft
Caliper:	0-285 ft
Density/Neutron:	0-285 ft

Type fluid in hole: water
from drillhole to 120 ft
Res mud: n/a
Res mud filtrate: n/a
Max. Rec. Temp.:
not recorded

General Lithologic Symbols Used



Dolomite
Mudstone/siltstone
Anhydrite
Halite



Fine sandstone & siltstone
Coarse sandstone
Sandstone w/caliche
Polyhalite

Figure 2-1 Log Title & Header page.ai

SNL-16 Well Log Headers

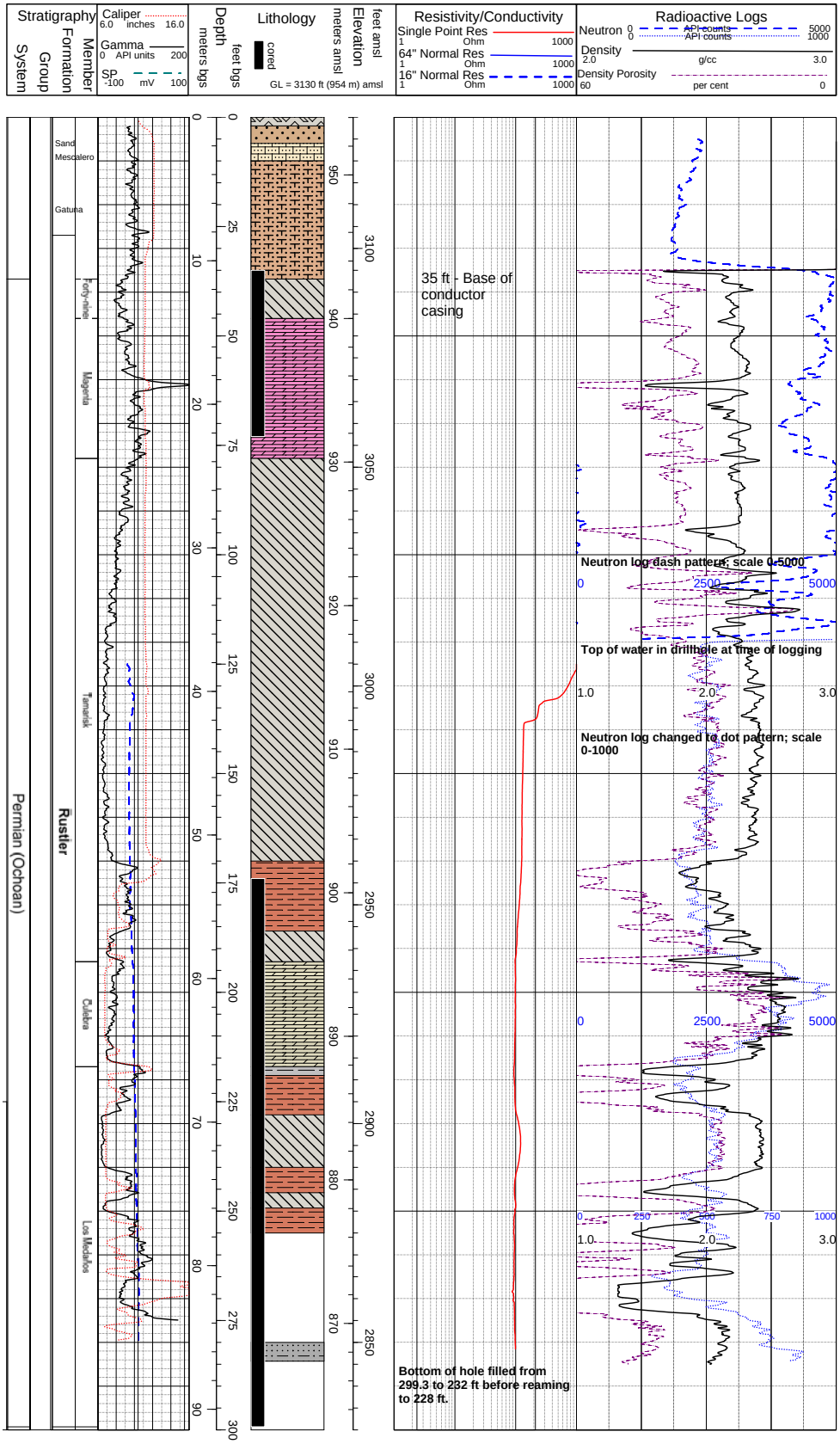
Radioactive Logs
Neutron 0 0 API counts
Density 2.0 3.0 g/cc
Density Porosity 60 0 per cent

Resistivity/Conductivity
Single Point Res 1 1000 Ohm
64" Normal Res 1 1000 Ohm
16" Normal Res 1 1000 Ohm

feet amsl
Elevation
meters amsl
Lithology
cored
GL = 3130 ft (954 m) amsl
feet bgs
Depth
meters bgs

Caliper 6.0 16.0 inches
Gamma 0 200 API units
SP -100 100 mV

Stratigraphy
Member
Formation
Group
System



See end of Appendix G for larger format pdf version

Table 2-1
Geology at Drillhole SNL-16

System/ Period/Epoch		**Formation or unit**	**Member** *Informal units*	**Depth below surface (ft)**[1] *log depths*	*core marks*
Cenozoic	Holocene	surface dune sand and pad fill		0 - 6 ft	
	Pleistocene	Mescalero caliche		6 ft - 10 ft	
	Miocene-Pleistocene	Gatuña		10 ft - 37 ft	36.3 ft - 37.6 ft
Mesozoic	**Triassic**	Santa Rosa[2]		eroded	
		Dewey Lake[3]		eroded	
Paleozoic	**Permian**	Rustler	Forty-niner *A-5* *M-4/H-4* *A-4*	37 ft - 46 ft *eroded* *eroded* *37 ft - 46 ft*	37.6 ft - 44.4 ft *eroded* *eroded* *37.6 ft - 44.4 ft*
			Magenta Dolomite	46 ft - 78 ft	
			Tamarisk *A-3* *M-3/H-3* *A-2*	78 ft - 193 ft *78 ft - 170 ft* *170 ft - 186 ft* *186 ft - 193 ft*	 *184 ft - 190.6 ft*
			Culebra Dolomite	193 ft - 217 ft	190.6 ft - 215.3 ft
			Los Medaños[4] *M-2/H-2* *A-1* *M-1/H-1*	217 ft - 299.3 ft *217 ft - 228 ft* *228 ft - 240 ft*	215.3 ft - 299.3 ft *215.3 ft - 226.2 ft* *226.2 ft - 239 ft* *239 ft - 299.3 ft* [5]

[1]Depths are based on measurements by geophysical logging; drilling and coring provided supplemental data to TD of 299.3 ft bgl by driller's log. Geophysical logs and drilling/coring depths begin at the top of the connector on the surface steel conductor casing. This reference point is taken as 3,130 ft amsl; it is near the elevation of the surface benchmark adjacent to SNL-16. Water level depths will be measured and reported relative to the surveyed point on the top of the fiberglass reinforced plastic casing (Fig. 1-5). Geological logs based on field descriptions (Appendix C) and markings on cores (Appendix F) vary modestly from log depths. Geophysical logs did not reach TD.

[2]The Santa Rosa and Dewey Lake Formations have been removed by erosion in this area.

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

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

[5]TD by drilling is 299.3 ft. The material recovered at TD was not marked for depth.

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

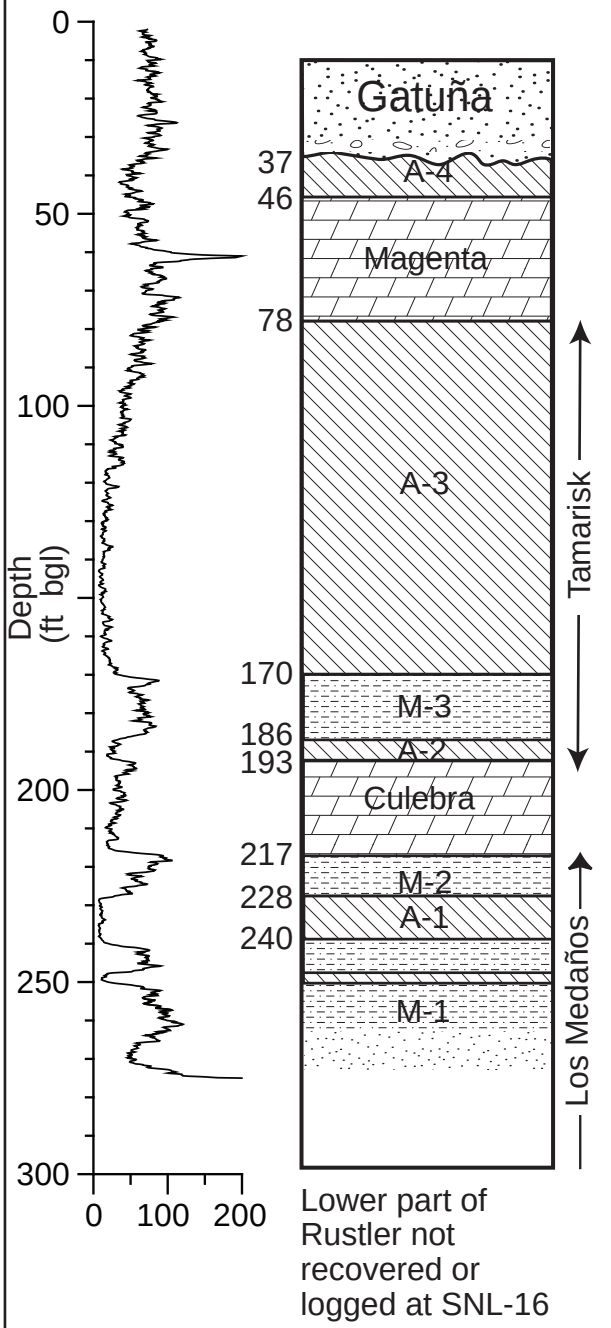
Much of the Los Medaños was cored (82.3 ft) in SNL-16, penetrating through M-2, A-1, and into mudstone facies (M-1) of M-1/H-1. Recovery was very limited in the bottom 45-ft-thick interval.

The informal unit *mudstone-halite 1* (M-1; Fig. 2-2) was encountered from 299.3–239.0 ft bgl, based on coring depths, and recovery was good above ~250 ft and minimal below that. Geophysical logs on this interval above ~285 ft indicate the top of M-1 is at 240 ft. Geophysical logs (Figs. 2-1, 2-2), as well as very limited core, indicate some sandstone as well as brecciated mudstone.

The very limited (0.5 ft) core recovered from the final 30-ft cored interval and inability to log the lower part of the drillhole make it uncertain if any part of the upper Salado dissolution residue was encountered. Drilling and coring was terminated because recovery was so limited. Total depth was approximately where an undisturbed Rustler-Salado contact would have been below the Culebra.

The lower recovered core from run 9 includes sandstone that is laminated and also shows a rotated block. Clasts and cross-bedding indicate primary sedimentary features consistent with mudflat facies, but the interval has been affected somewhat by dissolution of underlying Salado. This core was attributed to the interval from 284.3–278.3 ft, but

Figure 2-2
Rustler Units at SNL-16



Formal and informal Rustler Formation units and depths at SNL-16 based on natural gamma log; below the gamma log, drilling depths correspond to core markings.

there is uncertainty in this depth assignment. Sandy siltstone recovered below the gypsum in this core run more likely represents the assigned interval (marked 253.0–249.3 ft). Small clasts of red and gray siltstone are intraclasts (Fig. 2-3). Some fine laminae are present and contorted. Gypsum clots and selenite are also present. This interval also indicates both primary sedimentary features consistent with other cores of the interval and some distortion likely due to dissolution of upper Salado halite and subsidence.

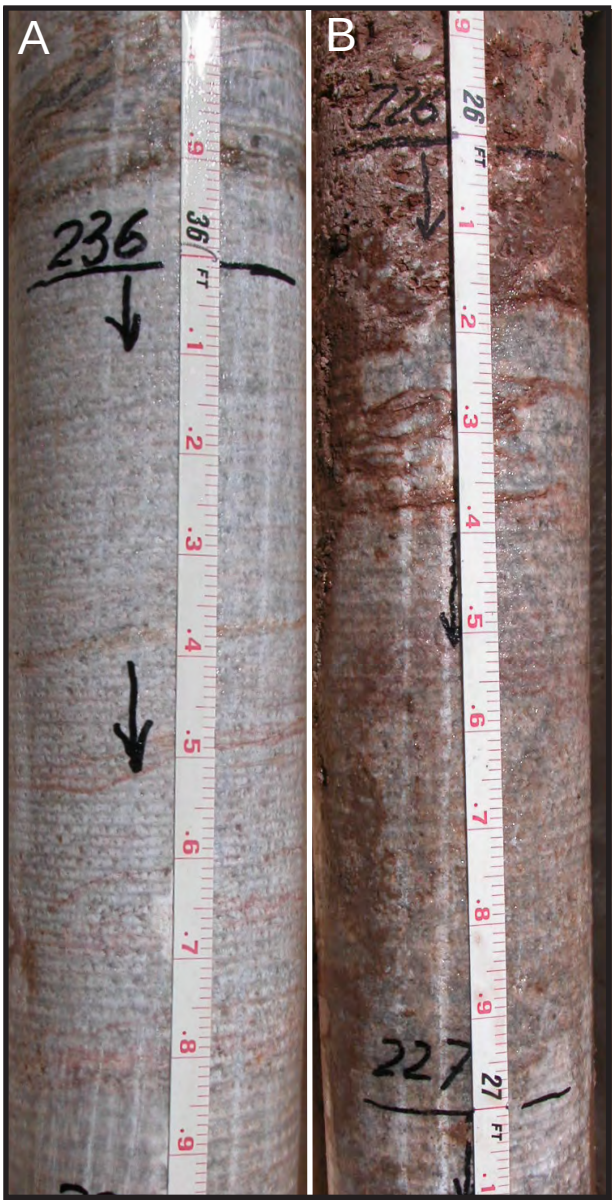
The 3.5-ft gypsum segment (marked 249.3–245.8 ft) is laminated. It also shows coarse clear gypsum, vuggy zones, and possible brecciation, with thin siltstone beds in the lower half and some displacive halite near the base.

The 6.8-ft silty claystone at the top of M-1 is red (2.5YR5/6) matrix with clasts of gray siltstone. Bedding is faint. Siltstone is washed out locally, and the unit becomes siltier upwards and weak red (2.5YR5/2) to gray at the top. Smeared intraclasts (Powers and Holt, 2000) may be present, indicating some synsedimentary halite dissolution.

The informal unit *anhydrite 1* (A-1; Fig. 2-2) was encountered from 239.0–226.2 ft based on core data (240–228 ft log data). A-1 is white to light gray laminated gypsum. Small gypsum growth crystals (0.125 inch high) appear to be present at different intervals on the core surface. Basal bedding is wavy to distorted and is wavy to subhorizontal upward (Fig. 2-4a). Wavy bedding at 235.9 ft was truncated by overlying wavy bedding. A near-vertical fracture, from 235.0–233.6 ft and filled with gypsum, ends at the base in coarser gypsum. Uppermost A-1 shows more deformation (Fig. 2-4b) and some possible solution and collapse from the top that may have developed on the mudflat during deposition of the overlying mudstone.

Figure 2-3. Siltstone clasts in upper M-1. Lighter siltstone clasts in reddish brown matrix of M-1 above thin sulfate bed in upper M-1.

Figure 2-4. "Anhydrite" 1 (A-1) at SNL-16. A - The lower part of A-1 shows well developed bedding in gypsum dips slightly. B - The upper part of A-1 shows more disrupted bedding in gypsum and possible solution and collapse below the contact with the overlying M-2 at 226.2 ft.



The informal unit *mudstone-halite 2* (M-2; Fig. 2-2) was encountered from 226.2–215.3 ft bgl, based on coring depths. The natural gamma log shows M-2 (Fig. 2-2) from 228–217 ft. The upper and lower contacts were recovered, but 4.5 ft of core were lost from the lower-middle M-2.

The basal contact with A-1 is sharp, slightly inclined, and probably erosional (Fig. 2-4b). The contact between M-2 and Culebra was also recovered (Fig. 2-5); contact bedding is deformed, while slightly deeper bedding appears little deformed.

The basal silty claystone is red (2.5YR4/6) and includes slightly darker red clasts of silty claystone and small gypsum clasts (Fig. 2-4b). Bedding is indistinct. A short vertical fracture is filled with gypsum, and some subhorizontal separations are filled with fibrous gypsum.

From base upward, the upper 4 ft of core recovered from M-2 is dark reddish brown (2.5YR4/4) silty claystone with rounded gray siltstone clasts; sandy siltstone that is gray (5Y6/1), mottled, and finely laminated to cross-laminated with small clasts or bioturbation; and dark gray (5Y4/1) silty claystone with laminae that range from undeformed to deformed upward. These features are consistent with soft deformation as Culebra was being deposited and with underlying mudflat facies deposited with little to no halite.

2.2.1.2 Culebra Dolomite Member

Based on drilling depths available at the time, the recovered Culebra core from SNL-16 was marked from 215.3–190.6 ft bgl (as used in information in Appendices C and F). The natural gamma log shows Culebra from 217–193 ft bgl (Fig. 2-2). Culebra core (Fig. 2-5; Appendix C) recovery was variable, with the most significant loss in the lower middle part of the member.

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

Figure 2-5 Culebra Dolomite Member of the Rustler Formation at SNL-16

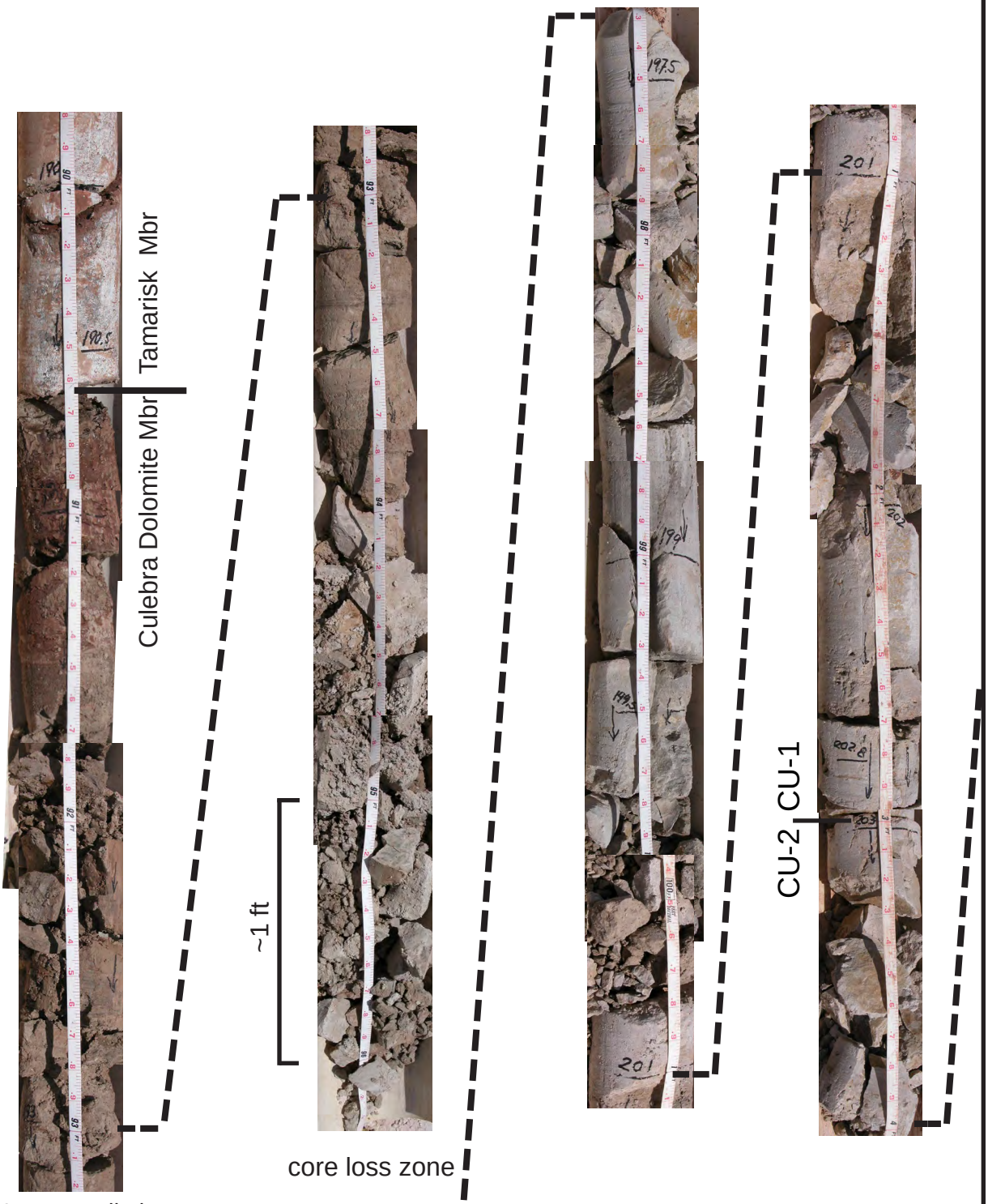
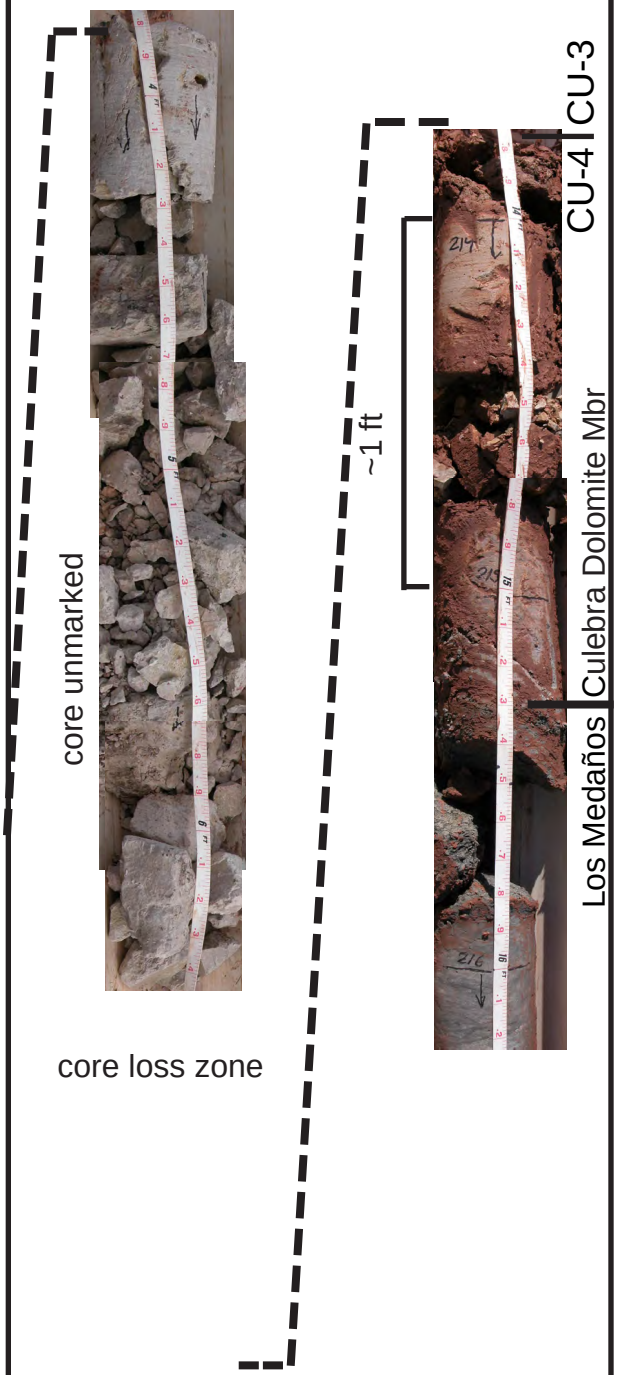


Figure 2-5 continued



common. Incomplete recovery of core at SNL-16 is likely due to fracturing and porosity collapse. Drilling used compressed air and mist, which have enhanced recovery of Culebra core in other wells.

The basal dolomite (215.3–213.8 ft) recovered in core from SNL-16 is generally white (2.5Y8/2), fine grained, and laminar with some open porosity in a small fracture. The laminae are deformed to ~30º at the base consistent with the deformed claystone immediately below the Culebra.

Limited core recovered between 213.8–203.8 ft indicates laminar fine dolomite with rare, large, open vugs and some small pinhole vugs.

Dolomite from 203.8–194 ft is light gray (10YR7/2) and brown to pale brown (10YR5/3-6/3; damp) above 194 ft. Very thin dark laminae are observable above 194 ft. Fractures are common throughout this interval, with no visible displacement. Fractures are stained yellowish brown below 197.3 ft.

The hydrostratigraphic units proposed for the Culebra by Holt (1997) are not easily assigned at SNL-16 (Fig. 2-5), in part because of core loss. Depths used below are based on core markings.

The most likely equivalent to the basal CU-4 hydrostratigraphic unit occurs from 215.3–213.8 ft. It has bedding, is fine-grained and white, and exhibits limited porosity. The basal contact is deformed. In the WIPP site area, this zone shows some fracturing, and the basal contact is usually slightly deformed by fracturing.

From 213.8–~203 ft, recovery is very limited. There is some evidence of vuggy porosity. The entire interval is tentatively assigned to CU-3 and CU-2 (Holt, 1997). This interval is thinner than typical combined thickness of these hydrostratigraphic units where assigned in wells with better recovery.

From ~203–190.6 ft, the dolomite is fine-grained, has few vugs, and is bedded, with an organic-rich zone near the top. A few sub-vertical fractures show no gypsum (Fig. 2-5) and some collapse. This interval tentatively corresponds

to CU-1 (Holt, 1997), although it is somewhat thicker than CU-1 toward WIPP.

The geophysical logs (Fig. 2-1) of the Culebra provide a few additional details of the unit. Resistivity remains generally low from upper M-2 through the Culebra and the lower Tamarisk before decreasing further (see Section 2.2.1.3). Neutron counts increase through the Culebra compared with underlying M-2 and overlying A-2. This is a probable response to the lack of gypsum in the Culebra at SNL-16. The density log shows higher values in most of the Culebra with a decrease at the top. The core observations of vugs and gypsum are generally consistent with log properties. Overall, the log properties through the Culebra and core character indicate that the Culebra is likely to have moderate or higher transmissivity based on field observations.

2.2.1.3 Tamarisk Member

The natural gamma log of SNL-16 shows that the Tamarisk occurs from 193–78 ft bgl (core marked 190.6 ft at base; upper contact not cored). Three basic subunits comprise the Tamarisk: a lower anhydrite, a middle halite and/or mudstone, and an upper anhydrite; all three are clearly shown by geophysical logs and the lower two were recorded by cores in SNL-16. Powers and Holt (2000) labeled these A-2, M-3/H-3, and A-3, respectively, and showed that the lateral gradation from mudstone M-3 to halite H-3 generally reflects lateral changes in deposition. SNL-16 is located in the M-3 facies (mudflats or saline mudflats) of these beds, ~6 miles west of the H-3 margin (see Section 4.0). The lower 11 ft of M-3 and all of A-2 were cored; the remainder of the unit is described on the basis of cuttings and geophysical logs.

The informal unit anhydrite 2 (A-2; Fig. 2-2) at the base of the Tamarisk is 7 ft thick (193–186 ft) based on the geophysical logs (core depths marked 190.6–185 ft). The core is predominantly white to gray gypsum. It is medium grained to very coarsely crystalline. Laminae and thin beds are preserved near the base. A corroded surface from 189–188 ft shows silty claystone (2.5YR4/4) and infilled clasts (Fig. 2-6A). Silty claystone occurs at 186.8–186.5 ft and gray siltstone at 185.5 ft. A fracture at 190 ft shows clay infilling. There are other fractures at ~45º from horizontal.

A-2 is divided in most locations by a dark gray siltstone. This clastic unit within A-2 is commonly indicated in natural gamma logs with a small spike in counts. Neither the core nor log indicate this siltstone with certainty. The gray siltstone at 186.8–186.5 ft is stratigraphically deeper than is common for this unit.

Surfaces, fractures, and clastic fill indicate A-2 has likely been partially dissolved with infiltration of fines from above.

The informal Tamarisk unit mudstone 3 (M-3; Fig. 2-2) at SNL-16 is 16 ft thick (186–170 ft bgl), based on the natural gamma log. The basal contact was marked at 185 ft. The lower 11 ft was cored.

The cored interval of M-3 is mudstone that is dark reddish brown (2.5YR3/4) with angular to subangular clasts of laminated medium to dark gray (2.5YRN5-6) siltstone and angular to subrounded clasts of lighter brown or red (2.5YR5/8) siltstone. Blocks of gypsum near the base are angular to subround (Fig. 2-6B). There is neither obvious bedding nor observable fining upward of the clasts. Clasts tend to orient with long axis subhorizontal. Low angle (<40º from horizontal), gypsum-filled fractures or separations are common in the upper 4 ft of core.

The geophysical log (Fig. 2-1) for M-3 shows common characteristics of the mudstone facies: an increase in natural gamma with low neutron and low density. The caliper log, density log, and, to a lesser extent, the gamma log all display differences between the lower and upper part (divided at ~176 ft) that are consistent with differences in sediment and color, but core and cuttings were insufficient to confirm this difference.

The informal Tamarisk unit anhydrite 3 (A-3; Fig. 2-2) at SNL-16 is 92 ft thick (170–78 ft bgl) based on geophysical logs; neither base nor top was cored.

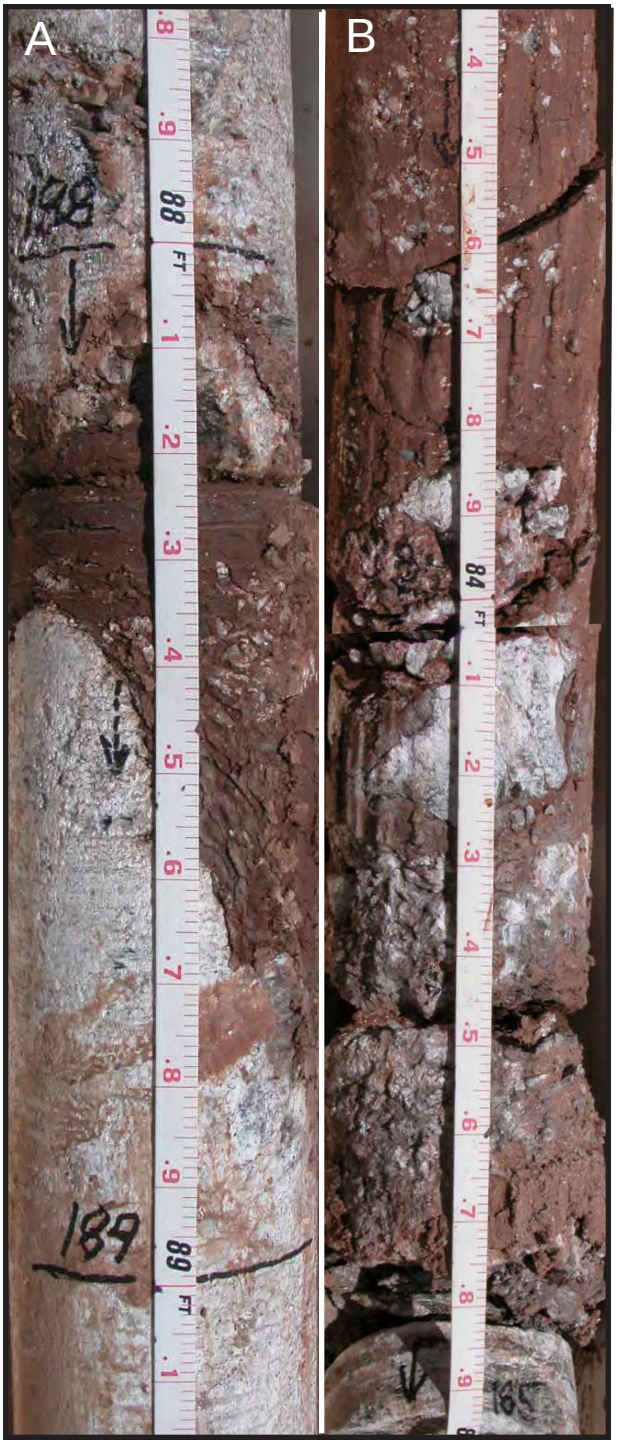


Figure 2-6. Tamarisk Member cores. A. Coarse gypsum of A-2 has been eroded and dissolved, with some collapse of mudstone clasts. B. Intraclasts of gypsum and siltstone at the base of M-3.

A-3 cuttings showed fine, white to gray gypsum with some coarse, clear gypsum.

Geophysical logs show top of fluid level at 120 ft, increase in natural gamma in the interval from 120–78 ft, varying neutron above the fluid level from 120–100 ft, high neutron from 100–78 ft, fluctuating density from 120–90 ft, and higher density from 90–78 ft.

A borehole video (Appendix G) showed fractures and small openings at ~97 ft depth, with some water flow.

2.2.1.4 Magenta Dolomite Member

Based on geophysical logs, the Magenta at SNL-16 is 32 ft thick (78–46 ft), while an incomplete core of the Magenta (Fig. 2-7) was taken and marked from 73–44.4 ft. This is thicker than is normal for the member. The base of Magenta was not cored.

The Magenta is weak red (2.5YR5/2) dolomite and white gypsum that is bedded to laminar and mildly wavy bedded. High-amplitude wavy stromatolitic beds commonly found near the base of the Magenta were not present and were likely not cored. White nodular gypsum was found at 51.0–50.0 ft (marked 52.5–51.5 ft). Some small possible vugs occurred at 63.3 ft. Most fractures at higher angles and separations along bedding planes included fibrous gypsum. A high-angle fracture from 64.5–64.9 ft is stepped, shows no weathering, and has no gypsum fill. A fracture at 44.2 ft also shows no gypsum. Various zones in the upper part of the Magenta are dominated by gypsum.

Geophysical log data from the Magenta show a zone of extra high natural gamma and slightly larger caliper from 62–60 ft. No particular feature in the core stands out as equivalent (63.5–61.5 ft core markings). Density and gamma are both diminished somewhat in the interval from 71–62 ft. Neutron counts vary through the Magenta. Resistivity was not obtained through the Magenta, as fluid level was well below Magenta at time of logging.

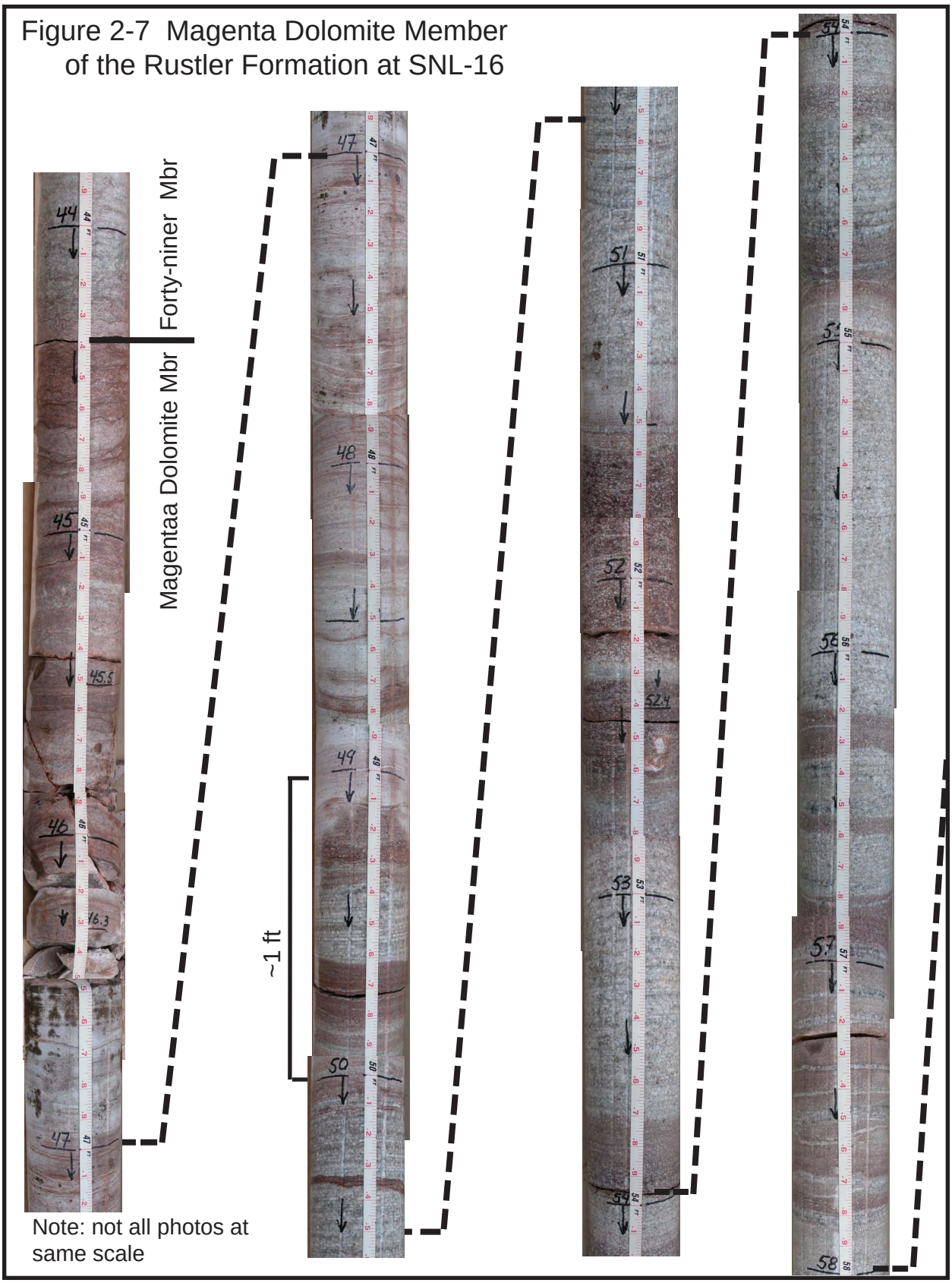
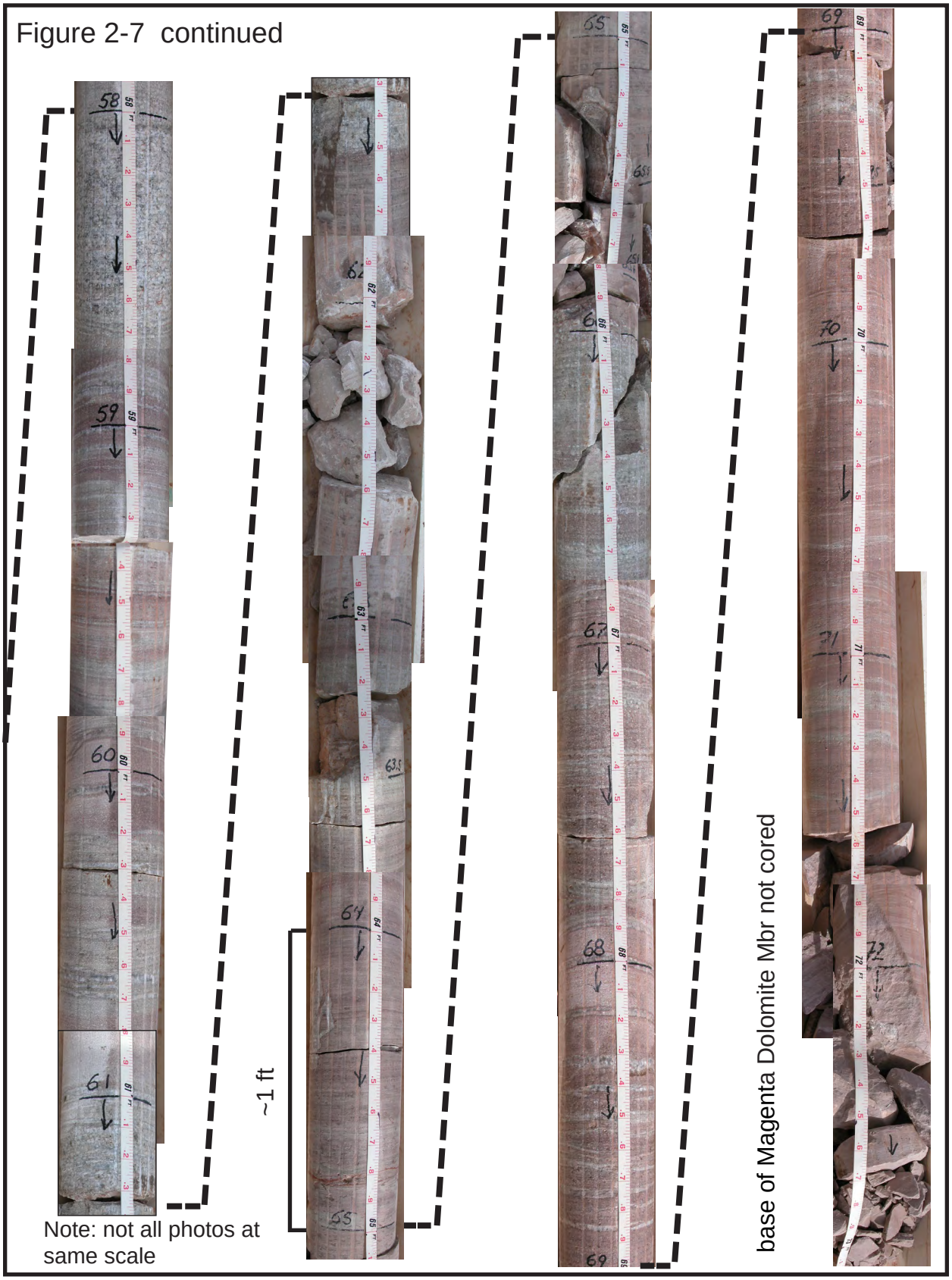


Figure 2-7 Magenta Dolomite Member of the Rustler Formation at SNL-16

Figure 2-7 continued



2.2.1.5 Forty-niner Member

Based on geophysical logs, the Forty-niner at SNL-16 is 9 ft thick (46–37 ft), with core from this interval marked 44.4–37.6 ft. The Forty-niner is described on the basis of cuttings, core, and geophysical logs. Like the Tamarisk, intact Forty-niner consists of upper and lower anhydrites with a middle unit that is a mudstone or halitic unit. Powers and Holt (2000) informally designated these units as A-4, M-4/H-4, and A-5, from bottom to top. They attributed the lateral relationship between clastic beds (M-4) and halite (H-4) to depositional facies of mudflat–saline mudflat–saltpan environments.

At SNL-16, erosion has removed the upper anhydrite (A-5) and the mudstone (M-4).

The lower unit, anhydrite 4 (A-4; Fig. 2-2), is mainly white gypsum with weak red banding and reddish gypsum and siltstone near the top of the core. A-4 is 9 ft thick (46–37 ft), based on geophysical logs, and the cored interval is marked from 44.4–37.6 ft. The gypsum is bedded to laminar in some intervals. Small, possible gypsum growth features occur from 37.1–37.8 ft. Stylolites in the lower few feet have relief up to 0.5 inch. A fracture at 42.1 ft at ~45º displays neither fill nor surface staining.

2.2.2 Permo-Triassic Dewey Lake Formation

The Dewey Lake Formation has been removed by erosion at SNL-16.

2.2.3 Miocene-Pleistocene Gatuña Formation

The Gatuña is ~27 ft thick (37–10 ft) based on logs and cuttings. Core is marked from 37.6–36.3 ft. Dark red siltstone above A-4 is heavily veined with gypsum. The red siltstone is assigned to the Gatuña, and it is probably disturbed and redeposited M-4. Magenta clasts at the top of the core have been redeposited after being eroded from somewhere near, likely nearby and to the northeast. The upper Gatuña is red (2.5YR5/8) to light red (2.5YR6/8) sandy siltstone that is poor to moderately lithified. Sandstone with small pebble conglomerate of small (0.2 inch) dark chert pebbles overlies the siltstone. Near the top, the Gatuña is white to pink (5YR8/3 sandstone with rounded grains and is moderately lithified.

Powers and Holt (1993) described Gatuña distribution, lithology, and depositional environments in the WIPP area.

2.2.4 Pleistocene Mescalero Caliche

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

At SNL-16, the Mescalero is 4 ft thick (10–6 ft) based on cuttings. It is a white, sandy limestone with subround to round sand grains.

Bachman and Machette (1977) classified six useful stages of pedogenic calcrete development, ranging from I as the least developed to VI morphologies showing multiple generations of calcrete development. ("Pedogenic calcrete" is preferred by many geologists and pedologists over the term "caliche" because of the wide variation in use of the latter term.) The Mescalero could not be classified at SNL-16.

2.2.5 Surficial Deposits

Construction fill (2 ft) and sand up to 4 ft thick were encountered at the drillhole location. Sand from 6–2 ft is reddish yellow (5YR6/8), very fine to medium, subround to round, and friable to slightly lithified. It is calcareous. This interval is likely equivalent to the Berino soil (Chugg and others, 1971).

3.0 PRELIMINARY HYDROLOGICAL DATA FOR SNL-16

SNL-16 was drilled specifically to test confinement of the Culebra within Nash Draw, monitor possible recharge in the area, and provide a replacement for WIPP-26. Water levels from the Culebra Dolomite Member of the Rustler Formation are being monitored.

3.1 Checks for Shallow Groundwater Above the Rustler Formation

The hole was drilled with compressed air to 123 ft, which is in the Rustler Formation. No moisture was observed in the drillhole above the Rustler.

3.2 Initial Results From the Magenta Dolomite

The Magenta (78-46 ft, log depth) was cored and reamed with compressed air with no observed inflow.

3.3 Initial Results From the Tamarisk Member

At 95 ft (A-3), while drilling on April 12, 2006, cuttings and air were moist. After a 1-hour shutdown, an estimated 5 gallons of water were blown from the drillhole using compressed air. Drilling continued to 123 ft using compressed air, and then compressed air with foam was used to drill to 174 ft. Drilling was shut down at 1715 hrs (CDT) on April 12 and the hole was blown with compressed air. A video (Appendix G) camera was run downhole and water was observed seeping into the drillhole from a fracture intersected from ~97–95 ft. A miniTroll was set at 170 ft for overnight observations.

The miniTroll was removed from the drillhole early on April 13. The water level was measured 119.7 ft below pad level at 0605 hrs, April 13, 2006. The estimated average production is 0.36 gallons per minute (gpm), and the recorded pressures by the miniTroll (Fig. 3-1) indicate the water level had not reached an equilibrium level at that time. The source was clearly higher, presumably at the fracture from ~95–97 ft.

A catch sample blown from the drillhole as the core barrel was advanced yielded a field-measured specific gravity of ~1.01 (see remarks, Appendix C, sheet 3).

3.4 Initial Results From the Culebra Dolomite and Deeper

On April 13, 2006, coring with mist advanced to 213.8 ft, ~23 ft into the Culebra. The coring ended at 1630 hrs (CDT), and a miniTroll was installed at 170 ft bgl by 1730 hrs (CDT).

Water level measurement was inconclusive on the morning of April 14. Pressure readings for the miniTroll (Fig. 3-1) indicate that the water level remained essentially unchanged from the time the miniTroll was installed; a static level was reached within ~1 hr after coring stopped. The pressure value was less than last recorded at the drillhole depth of 174 ft. Water was then blown from the drillhole from a depth of ~120 ft while the core barrel was being advanced in the drillhole.

SNL-16 was cored to 224.3 ft by ~0830 hrs (CDT) on April 14, reaching the lower part of M-2 below the Culebra. A miniTroll was installed at 170 ft by ~1010 hrs (CDT). On April 17, the miniTroll was removed, and water level was measured, with some uncertainty, at 110.5 ft bgl. Pressure readings for the miniTroll (Fig. 3-1) indicate that the water level remained essentially unchanged from the time the miniTroll was installed, indicating that a static level was reached within ~1.5 hrs. The pressure was similar to that recorded at the drillhole depth of 213.8 ft, before the Culebra was completely penetrated.

A field sample of water blown from the drillhole at a depth of 284 ft had a field-measured specific gravity of ~1.08 (remarks, sheet 4, Appendix C).

After reaching a depth of 299.3 ft (lower Rustler) at 1625 hrs (CDT) on April 17, the

miniTroll was reinstalled in SNL-16 at a depth of 170 ft by 1705 hrs (CDT). It was removed early April 18, and the water level was ~120 ft bgl at 0700 hrs (CDT). Recorded pressures (Fig. 3-1) indicate that water levels in the drillhole had reached essentially a static level in the 40 minutes between ending coring and installing the miniTroll. The measured water level and pressure readings were very similar to those recorded on previous days (Fig. 3-1).

SNL-16 was completed with FRP casing with 0.070-inch slots (Fig. 3-2). The annulus behind the screen was loaded with 4/10 gravel (Fig. 3-3). The Culebra above the gravel was isolated using HolePlug®, and the annulus above the seal was filled with cement (Fig. 3-4).

The well was jet-cleaned on April 25, 2006, with 100 barrels of Eunice city water. There were no returns to the surface. A pump was installed to develop the well. On April 26, 2006, the water level was 123.50 ft below top of FRP. The well was pumped for 9.5 hrs at ~14 gpm. The water started at a specific gravity of 1.005 and temperature of 19.1ºC, and it ended at 1.009 and 23.6ºC.

WRES began monthly water-level monitoring of the Culebra on September 12, 2006; the initial depth to water was 121.10 ft below the top of casing (U.S. DOE, 2007). A pumping test was conducted at SNL-16 between June 5 and June 9, 2006. A pressure density survey of SNL-16 was conducted July 26, 2006 (U.S .DOE, 2007).

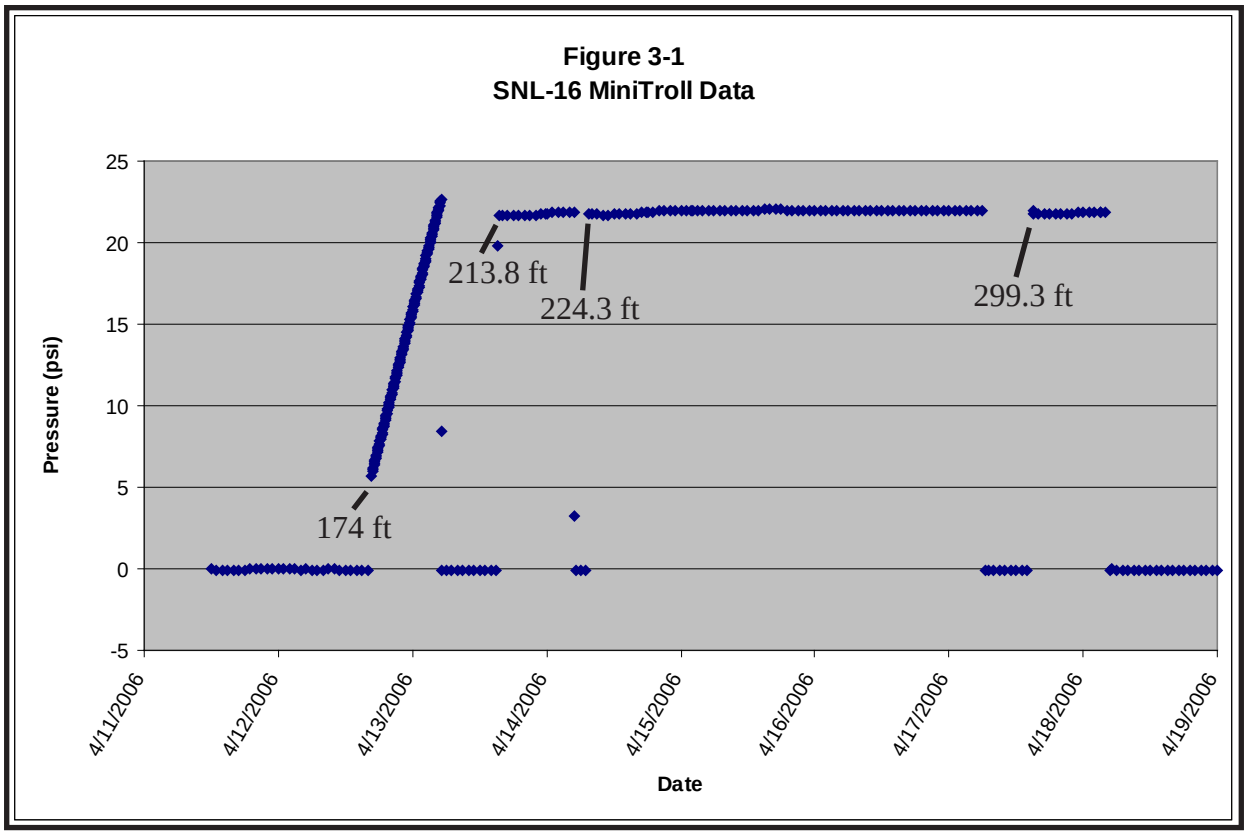


Figure 3-1. Plot of pressures measured by miniTroll in SNL-16 during drilling and coring period. MiniTroll was allowed to run continuously and was placed at a depth of 170 ft each recording period. Bottom of hole is shown at the beginning of each recording period.

Figure 3-2. Screen used in SNL-16 with 0.070-inch slots. Photo by Dennis W. Powers.

Figure 3-3. Gravel pack for SNL-16. Super sack of 4/10 gravel pumped into SNL-16 behind screened interval. Photo by R.G. Richardson.

Figure 3-4. Cementing SNL-16 annulus. Cement truck unloading cement into cement pump at SNL-16 to fill annulus above gravel pack and bentonite seal. Photo by Dennis W. Powers.

4.0 SIGNIFICANCE/DISCUSSION

The materials used in completing SNL-16 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.

Most of the lower Rustler was penetrated at SNL-16. Core recovery was too limited to determine the stratigraphic position with certainty at TD. Previous studies of thickness changes between the Culebra and Vaca Triste Sandstone Member of the Salado (Powers, 2002a, 2003, 2007; Powers and others, 2003, 2006) indicated that SNL-16 is located west of the upper Salado halite margin, and it is in the area where upper Salado halite has been dissolved (Fig. 4-1). SNL-16 is also located considerably west of all margins of halite in the Rustler Formation (Fig. 4-1). No halite was encountered in SNL-16.

Recovered core from the Los Medaños displays sedimentary features that are little deformed by upper Salado dissolution. Intraclasts below A-1 mainly indicate depositional relationships as were proposed by Holt and Powers (1988) and Powers and Holt (2000). Some fracturing and movement are superimposed on the sediments. Deformed and undeformed laminae at and below the Los Medaños-Culebra contact are consistent with the depositional model and synsedimentary soft deformation at this contact in other areas outside Nash Draw. Core from M-3 also displays some of the relationships attributed to depositional facies changes across the area.

Core recovery was variable from the Culebra, and most of the zone in the lower middle member that is normally most porous and transmissive was not recovered. Some of the Culebra core shows some evidence of porosity collapse that is attributed to dissolution in more modern times as the Rustler is more exposed and recharge to Culebra in the area increased.

A-2 in core is thinner than normal and also shows corroded and dissolved surfaces and infiltration of siliciclastics. These are also attributed to more modern exposure of Rustler and infiltration of meteoric water. Facies models developed to explain the distribution of Rustler halite and mudstone units (Holt and Powers, 1988; Powers and Holt, 2000) imply that exposure more distal to the halite pan facies (e.g., H-3) might well attack and thin A-2 during Permian time. The extent of such a process here at SNL-16 is unevaluated at this time.

Lower A-3 would be expected to show fracturing and block rotation in response to removal of H-3. Other wells to the east indicate that H-3 was not deposited this far from the halite pan, and these features would not be expected. Cored intervals did not include A-3. Video from SNL-16 after A-3 was drilled showed high-angle fracturing at ~95–97 ft with inflow to the drillhole estimated at less than ½ gpm. This fracturing may be related to subsidence after upper Salado dissolution. Holt and Powers (1988) inferred that fracturing due to subsidence after upper Salado dissolution would propagate upward with diminishing effects.

The Magenta core recovery was good. The core showed fractures, most of which were filled with gypsum. There was little other open porosity.

Only the lower sulfate of the Forty-niner is preserved at SNL-16. Gatuña overlying it included Magenta clasts.

The upper Forty-niner Member and Dewey Lake and Santa Rosa Formations have been completely removed at SNL-16 by erosion at an undetermined time before some Gatuña Formation deposition. Erosion, exposure of upper Rustler at the surface, and fracturing associated with subsidence after upper Salado halite dissolution contribute to the development of shallow karst features at SNL-16 and in the vicinity (Powers and others, 2006).

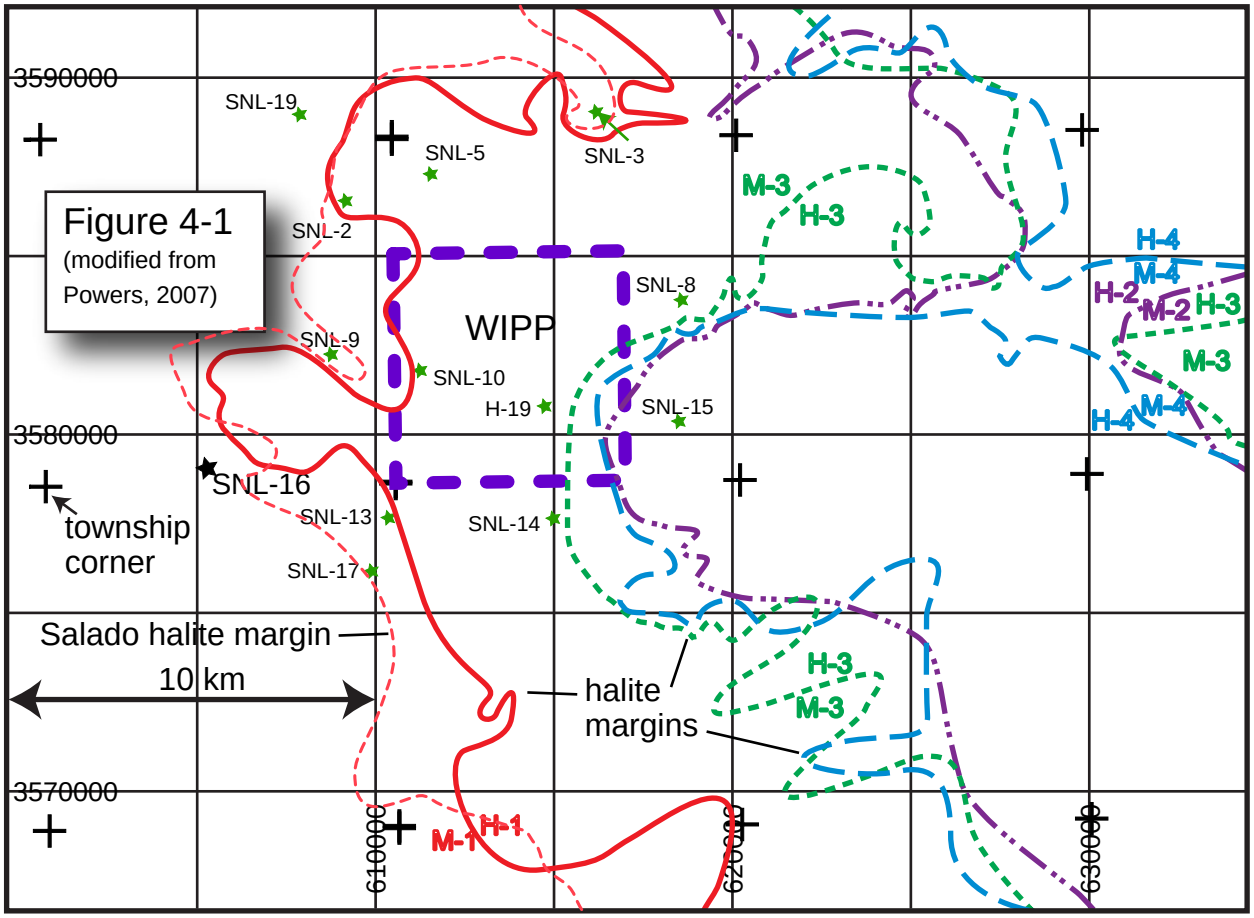


Figure 4-1. Location of SNL-16 relative to upper Salado dissolution margin and Rustler halite margins. SNL-16 is located in the southeastern arm of Nash Draw (Appendix A). Rustler cores indicate some disruption by upper Salado dissolution, but core recovery was minimal from the lower Rustler. Several other wells drilled recently are shown for reference. Modified from Powers (2007).

Water level measurements, miniTroll data, and downhole video taken during drilling all indicate that water inflow from the upper Tamarisk (A-3) is not well connected to the Culebra. Field-measured specific gravity also is consistent with different water sources. It seems likely that the A-3 sources are more directly connected to nearby surface recharge (see Powers and others, 2006; Powers, 2006). The Culebra is interpreted to be locally confined, although it is in an area expected to show varying degrees of confinement (Powers, 2006).

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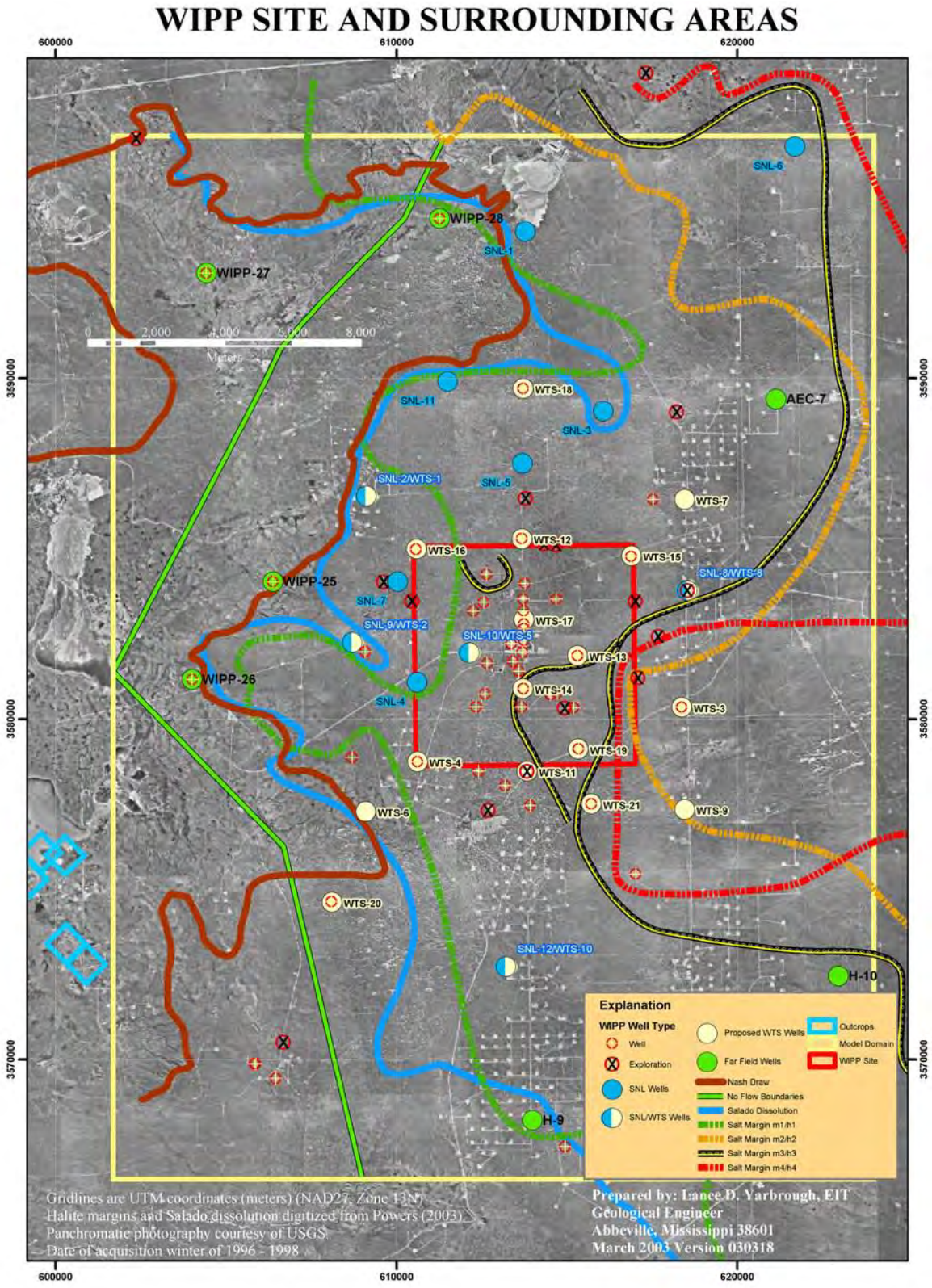
Appendix A
Drillhole Objectives

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.

SNL-16 is not listed specifically within the Groundwater Hydrology Program. A separate description of the selection process and geologic basis for locating this and other drillholes to be completed during FY06 was prepared. That document has been reproduced on the following pages. The original WIPP Integrated Groundwater Hydrology Program (Sandia National Laboratories, 2003) should be consulted for context for the program.

p. 27


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

p. 39:

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.

Dennis W. Powers, Ph. D.
Consulting Geologist

July 7, 2005

Ron Richardson
Field Lead
WRES

Rick Beauheim
Hydrology Lead
Sandia National Laboratories

Initial Locations of Three New Drillholes for FY2006

Five drillholes are expected to be drilled during FY2006 to develop information in support of studies of the hydrogeology of the Waste Isolation Pilot Plant (WIPP). These studies provide information for modeling the hydrologic regime near WIPP and understanding processes behind continuing rises in hydraulic head for the Culebra around WIPP. Summary information and results are provided to EPA as part of periodic mandated recertification of WIPP by EPA (Sandia National Laboratories, 2003).

Here I summarize background information and justification for three of these drillhole locations so permitting and supporting activities can proceed. Although these wells are first to be located specifically for FY2006, that does not imply that the locations will be drilled in this order.

SNL-10

No well number has been assigned by the Office of the State Engineer (OSE) (New Mexico) for this well because there has not been a previous permit application.

Location

SNL-10 is located within the land withdrawal area of WIPP, west of the site center (Figure 1). Field UTM coordinates (NAD27, Zone 13) for this location were obtained 6/6/05: 611217 m Easting, 3581777 m Northing. SNL-10 is adjacent to the railroad grade near the western boundary of the WIPP land withdrawal area. This location for SNL-10 is somewhat west of the original location proposed in the Hydrology Plan (Sandia National Laboratories, 2003).

Background for SNL-10

SNL-10 is located over the estimated boundary for halite in M-1/H-1 in the lower Rustler. Halite is not anticipated in M-2/H-2, just below the Culebra, or in either M-3/H-3 or M-4/H-4.

The Magenta Dolomite hydraulic properties are not known in the vicinity of SNL-10.

There is not expected to be significant water in the Dewey Lake Formation at SNL-10 based on general knowledge of the extent of the saturated zone in this unit (Powers, 2003a).

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

Dennis W. Powers, Ph. D.
Consulting Geologist

Justification for, and Scope of, SNL-10

The justification for this well remains as provided in the hydrology plan (Sandia National Laboratories, 2003, p. 45-46):

> A well in this location will help define the boundary between the high Culebra transmissivities at wells such as P-14 [C-2637] and WQSP-1 [C-2413] and the low transmissivities at wells such as H-2 [H-2b1 is C-2758] and H-14 [C-2766]. A well at the SNL-10 location will serve the following purposes:
>
> 1. provide transmissivity data in an area of the Culebra model domain where data are currently lacking;
> 2. provide data to define better the location of the m1/h1 halite margin and its effect on Culebra transmissivity; and
> 3. provide a monitoring location for a large-scale (multipad) pumping test (centered at SNL-9 [C-2950]) to provide transient data for calibration of the Culebra model on the west side of the WIPP site.
>
> In addition, a well at the SNL-10 location will provide needed information to help define the direction and rate of Culebra groundwater flow across the WIPP site, which is required for annual HWFP reporting to NMED (hence the parallel designation WTS-5). Putting a well at this location obviates the need to install a replacement well on the H-2 hydropad when the last Culebra well there has to be plugged and abandoned.

The general scope of the well is similar to recent wells for investigating hydraulic properties of the Culebra. As the well proceeds, the Dewey Lake will be checked for fluid inflow; it will be monitored for a short period (typically overnight) and sampled, if appropriate. The Magenta Dolomite will be cored (~30 ft), water levels will be monitored for a short period, and water will be sampled if appropriate. The lower Tamarisk through Culebra and into upper-mid M-1/H-1 will be cored (~140 ft) to define halite margins or cements. Culebra water may be sampled if conditions are appropriate, but this is more commonly done after the well has been developed. It is not anticipated that the lower Rustler and Salado contact will be drilled or cored. The hole will likely be about 650-675 ft deep, based on P-6 [no OSE designation], about ½ mile southwest of SNL-10. The lowermost part of the hole will be plugged back to a point 10-20 ft below the Culebra. The well will be completed with a single screened interval open to the Culebra at a depth to be determined based on drilling and logging; in the absence of a surveyed surface elevation at the proposed location, the estimated base of the ~ 26-ft screen interval is about 600 ft below ground level.

SNL-16

No well number has been assigned by the Office of the State Engineer (New Mexico) for this well because there has not been a previous permit application.

Location

No drillhole designated SNL-16 was included in the original hydrological program plan. SNL-16 is a new drillhole location in the SE ¼ of section 33, T22S, R30E (Figure 2). Field UTM coordinates (Zone 13, NAD27) for the location are 605170 m Easting, 3579010 m Northing. This location is about 95 m west and 27 m south of potash exploration drillhole D-221 [no OSE designation], originally drilled in 1961 and now plugged and abandoned. The proposed location is adjacent to the access road for the mine. Ownership maps indicate this is property administered by BLM.

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Consulting Geologist

Drillhole Locations for FY2006
July 7, 2005

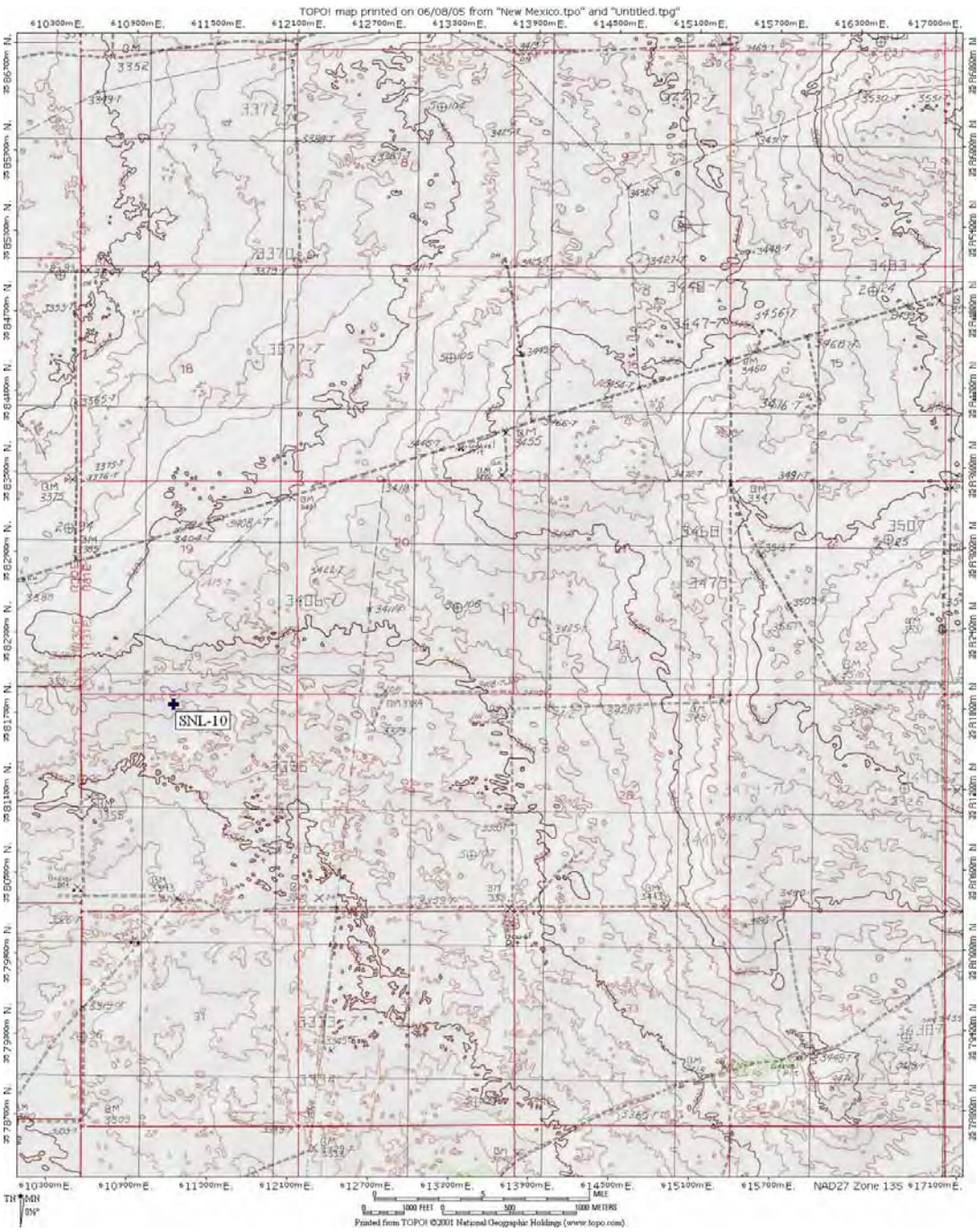

Figure 1. Location of SNL-10, a little more than 1.5 miles west of the center of the WIPP site land withdrawal area.

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Consulting Geologist

Background for SNL-16

Surface and subsurface data in the southeastern arm of Nash Draw are being integrated to develop a more thorough understanding of the geohydrologic influence of this area on the Culebra hydraulic properties at WIPP and behavior of the hydraulic system.

SNL-16 is located within the major integrated drainage basin that leads to a dense population of surface sinks and caves within a karst valley in the southeastern arm of Nash Draw (Powers, in preparation). It is also located in a small inset basin within this large basin. The location offers a specific opportunity to examine the relationship between Culebra hydraulic behavior and potential recharge events within the drainage basin. The location is believed to be within a transitional zone adjacent to Livingston Ridge where the Culebra behaves more nearly as confined than unconfined based on reports of conditions in wells about ¼ mile northwest of D-221 (Powers, in preparation).

Elevation contours of the reported tops of Rustler, Culebra, and "halite" from wells in this area show some common elements:

- A high on each unit parallels Livingston Ridge (Figures 2, 3, 4).
- A high on each unit underlies the general area of the surface mine facilities.
- Sparse data suggest that there is a zone of low elevation on each stratigraphic marker at the foot of the escarpment of Livingston Ridge between these areas.
- Low elevation (a crude "trough") trends roughly perpendicular to Livingston Ridge through the location of SNL-16 on the Culebra and top of "halite," although the top of Rustler does not show such a low.
- Surface drainage generally follows the elevation low.
- Surface sinks and stream capture occur down gradient from the SNL-16 location.

The surface and subsurface data indicate that there is a relationship between dissolution of halite from the upper Salado, structure on the Culebra, and surface drainage away from the escarpment of Livingston Ridge where the relationship between Salado dissolution and Culebra structure has previously been described (Powers and others, 2003). SNL-16 is located in an area to test the relationship and provide a monitoring point for hydraulic behavior with surface recharge events.

Mosaic Potash has provided access to a shallow well (C-2111) near their shaft area at the Nash Draw mine in section 33. Water levels have been monitored there since late 2004, revealing water level changes that differ from those in WIPP-26 [C-2724] and I-461 [no OSE designation]. Available data suggested C-2111 might have been completed in the Culebra, although depths were marginal. Very different mini-Troll data (compared to WIPP-26 and I-461) suggest that C-2111 is connected to a differing hydraulic system, and comparing data with SNL-16 will be useful.

Justification for, and Scope of, SNL-16

SNL-16 provides a location for

- testing confinement of the Culebra near the upper Salado dissolution margin,

- testing the relationship between potential surface recharge events and Culebra hydraulic events in a karsted drainage basin,
- obtaining detailed stratigraphic data on shallow units, and
- providing a general replacement for WIPP-26 in a strategic location to monitor hydraulic behavior along the southwestern area of the model domain.

The Culebra is relatively shallow at SNL-16; the top at D-221 was about 215 ft below ground level. It will be most helpful to get cores through the Culebra and well into the lower Rustler to compare fabrics and textures with other wells where upper Salado halite has not been dissolved. In addition, the Magenta is extensively involved in near-surface and surficial karst to the west within the same surface drainage basin. It will be very helpful to determine the extent to which the Magenta has been altered in this more upland position.

Any shallow groundwater above the Culebra will be monitored for a period of time to establish preliminary evidence of groundwater levels for comparison with Culebra groundwater levels. The Magenta (~30 ft) and the lower Tamarisk through lower Los Medaños will be cored (~170 ft). Total depth is estimated to be ~350 ft. The lowermost part of the hole will be plugged back to a point 10-20 ft below the Culebra. The well will be completed with a single screened interval open to the Culebra at a depth to be determined based on drilling and logging; in the absence of a surveyed surface elevation at the proposed location, the estimated base of the ~ 26-ft screen interval is about 225 ft below ground level.

SNL-17

No well number has been assigned by the Office of the State Engineer (New Mexico) for this well because there has not been a previous permit application.

Location

No drillhole designated SNL-17 was included in the original hydrological program plan. SNL-17 is located southwest of the WIPP site, in an area between SNL-13 [C-3139], H-7 [H-7b1 is C-2770], and SNL-12 [C-2954]. Two drillholes (WTS-6 and WTS-20) were included in the hydrology program (Sandia National Laboratories, 2003) in this general area, but these drillholes were principally to provide basic monitoring locations, including replacing H-7. SNL-17 is located for differing reasons.

SNL-17 is located in central section 12, T23S, R30E, near potash exploration drillhole I-445 (Figure 2). A preliminary field location has been staked at approximate UTM coordinates (Zone 13, NAD27) of 609852 m Easting, 3576021 m Northing. The location is about 250 m east and 220 m south of I-445 [no OSE designation]. SNL-17 is at the base of a small escarpment that is believed to be a continuance of the Livingston Ridge escarpment related to dissolution of upper Salado halite.

Dennis W. Powers, Ph. D.
Consulting Geologist

Background for SNL-17

There are two potash drillhole pads in this general area that I considered for locating SNL-17: I-445 and I-453 [no OSE designation]. The background source data I found for these two drillholes through the Rustler is better for I-445 than for I-453. I-445 provides better evidence of the geohydrologic setting through the Rustler. I-453 provides more separation from the escarpment.

Elevation data on top of Rustler, top of Culebra, and top of "halite" provide common elements and contrasts that guide location and objectives for SNL-17 (Figures 2, 3, 4):

- The elevations of top of Culebra and "halite" show marked lows at both drillholes, with I-445 distinctly lower.
- The elevation of top of Rustler at I-445 is generally reasonable, considering that it is reported in the file as top of Magenta Dolomite. It is lower than surrounding wells by about 20 m (about 66 ft), which is about the thickness of the Rustler above the Magenta in the area. The elevation as top of Magenta is consistent with surrounding wells. Gypsum reported at a depth of 50 ft is possibly part of the Gatuña Formation.
- The thickness between Magenta and top of Culebra is nearly three times normal (~280 ft instead of ~100 ft), suggesting lengthening of the section through subsidence. The thickness from top of Culebra to halite indicates either lengthening of the section through subsidence or a significant dissolution residue at the top of the Salado, assuming data are correct. For I-445, the file data also indicate another dolomite below that which was identified as Culebra. This may indicate disruption from subsidence, as other drillholes in the vicinity do not show an extra dolomite.
- Surface topography indicates that more complex valleys developed in this arm of Nash Draw, although they are masked by significant sand dune fill. The low points on Rustler, Culebra, and "halite" in this arm of Nash Draw and area of SNL-17 generally are consistent with the valley development.
- The escarpment in this area also likely developed from subsidence due to dissolution of upper Salado halite, consistent with the broader analysis in Powers and others (2003) and Powers (2001, 2003b).

Justification for, and Scope of, SNL-17

SNL-17 should provide good geological information bearing on how upper Salado dissolution relates to Culebra hydraulic properties and the development of an escarpment by testing on the side of the margin where dissolution has occurred. In addition, the well will also provide information about the degree to which the Culebra is confined near this margin. In contrast, hydraulic properties of the Culebra at H-7, well within the boundary of this zone of dissolution, indicate that the Culebra is not confined (Beauheim and Ruskauff, 1998). Based on reports from wells nearer the margin, the Culebra would appear to be confined or partially confined along a transitional zone (Powers, in preparation). SNL-17 should be in a very good location to monitor behavior of the hydraulic system under somewhat different conditions, in an area between several other wells (H-7, SNL-12, SNL-13, SNL-16). SNL-17 may eventually be found adequate to monitor groundwater in this area if all H-7 wells are plugged and abandoned.

Dennis W. Powers, Ph. D.
Consulting Geologist

Drillhole Locations for FY2006
July 7, 2005

The Magenta Dolomite Member would be cored, but I estimate ~45 ft may be necessary if this drillhole is as unusual as I-445 appears to be. I propose an additional 200 ft of coring for the lower Tamarisk, Culebra, and lower Rustler to obtain reasonable representation of these units. If practical, the drillhole will be extended into the upper Salado to an estimated total depth of 900 ft to intercept upper Salado marker beds. The lowermost part of the hole will be plugged back to a point 10-20 ft below the Culebra. The well will be completed with a single screened interval open to the Culebra at a depth to be determined based on drilling and logging. In the absence of a surveyed surface elevation at the proposed location and in view of the local structure created by upper Salado halite dissolution, the estimated base of the ~ 26-ft screen interval is in the range of 550-600 ft below ground level.

Summary Comments on Drillholes

These three locations for drillholes to be completed during FY06 are part of the overall program to address two of the principal components of the hydrology program (Sandia National Laboratories, 2003):

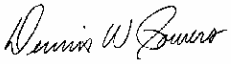
- Resolution of water-level changes
- Enhancement of groundwater models

The locations focus more heavily on possible effects on the hydraulic system of the Culebra in the southwestern area of the site, including part of Nash Draw. Surface hydrology and geohydrology factors from this area are being integrated into modeling, and they are explicit parts of the process of selecting these locations. Nevertheless, the location of either SNL-16 or SNL-17 may need to be modified if modeling results are available with sufficient lead time and warrant a significant change.

I have limited some of the coring and drilling projections for these drillholes as a compromise between prioritizing objectives and the likelihood of budget limitations to pursue some of the lesser priorities.

As a last point, these three locations, out of five anticipated for FY2006, are easier to evaluate than potential locations in the northern to northeastern part of Nash Draw to help resolve Culebra water level rises. Permitting processes for these three locations can proceed to ensure a more orderly contracting and drilling schedule. As potential locations for additional drillholes for FY2006 are evaluated and determined over the next few weeks, they may be drilled before one or more of these three locations because of the priority assigned to the information.

Sincerely,



Dennis W. Powers

Dennis W. Powers, Ph. D.
Consulting Geologist

References cited:

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

Powers, D.W., 2003b, Addendum 2 to Analysis report Task 1 of AP-088, Construction of geologic contour maps: report to Sandia National Laboratories, January 13, 2003 (ERMS # 522085)

Powers, D.W., Holt, R.M., Beauheim, R.L., and McKenna, S.A., 2003, Geological factors related to the transmissivity of the Culebra Dolomite Member, Permian Rustler Formation, Delaware Basin, Southeastern New Mexico, *in* Johnson, K.S., and Neal, J.T., eds., Evaporite karst and engineering/environmental problems in the United States: Oklahoma Geological Survey Circular 109, p. 211-218.

Sandia National Laboratories, 2003, Program Plan WIPP Integrated Groundwater Hydrology Program, FY03-09, Revision 0: Sandia National Laboratories, March 14, 2003.

Dennis W. Powers, Ph. D.
Consulting Geologist

Drillhole Locations for FY2006
July 7, 2005

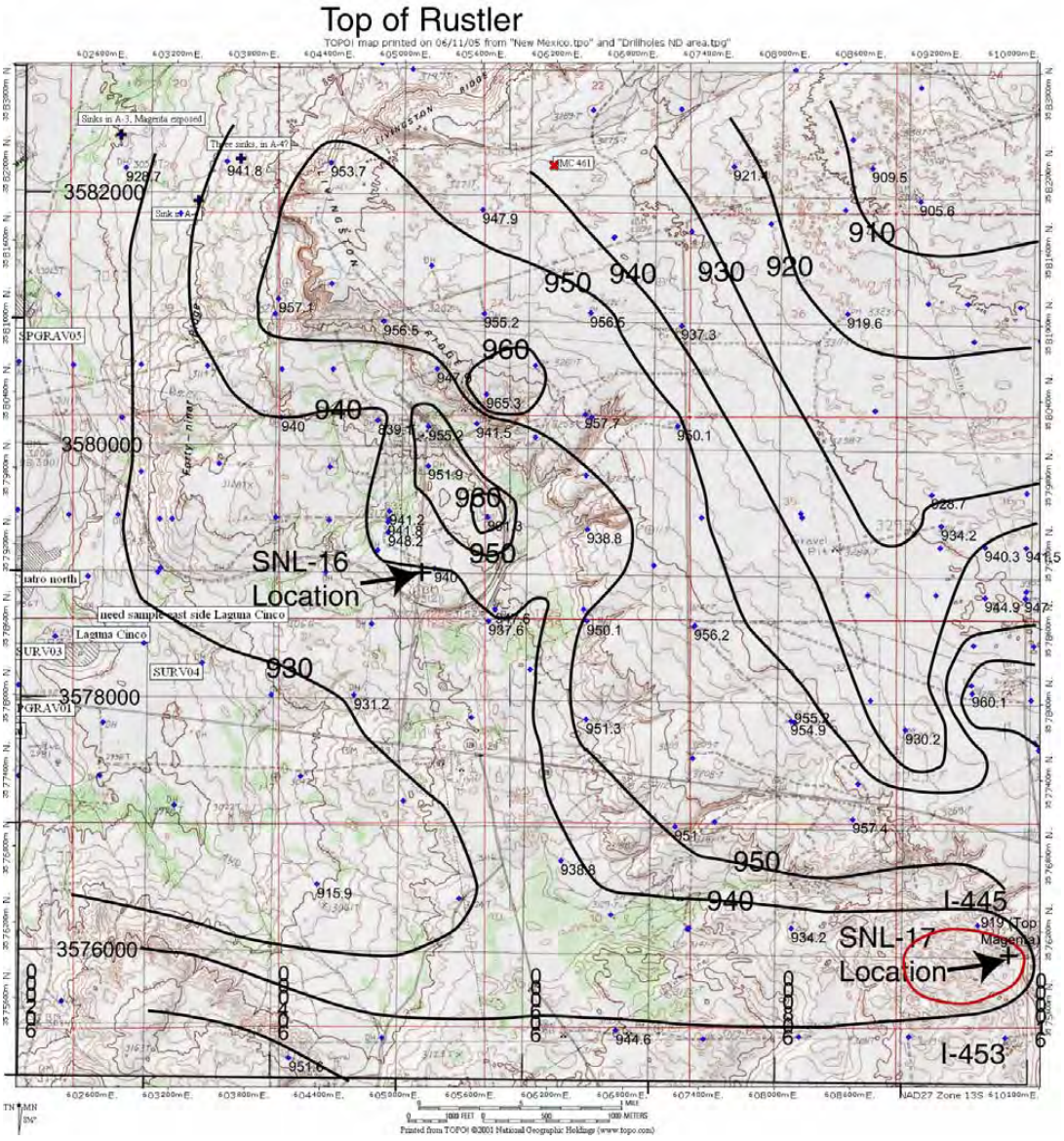


Figure 2. Elevation on uppermost unit assigned to the Rustler Formation in the vicinity of SNL-16 and SNL-17 proposed locations. Red contour lines indicate areas of elevation depressions or probable depressions. West of Livingston Ridge, this may not be the normal stratigraphic top of Rustler (top of Forty-niner Member) due to exposure and erosion. Units are meters above mean sea level. The value at I-445 is based on file report of top of Magenta as top of Rustler.

Dennis W. Powers, Ph. D.
Consulting Geologist

Drillhole Locations for FY2006
July 7, 2005

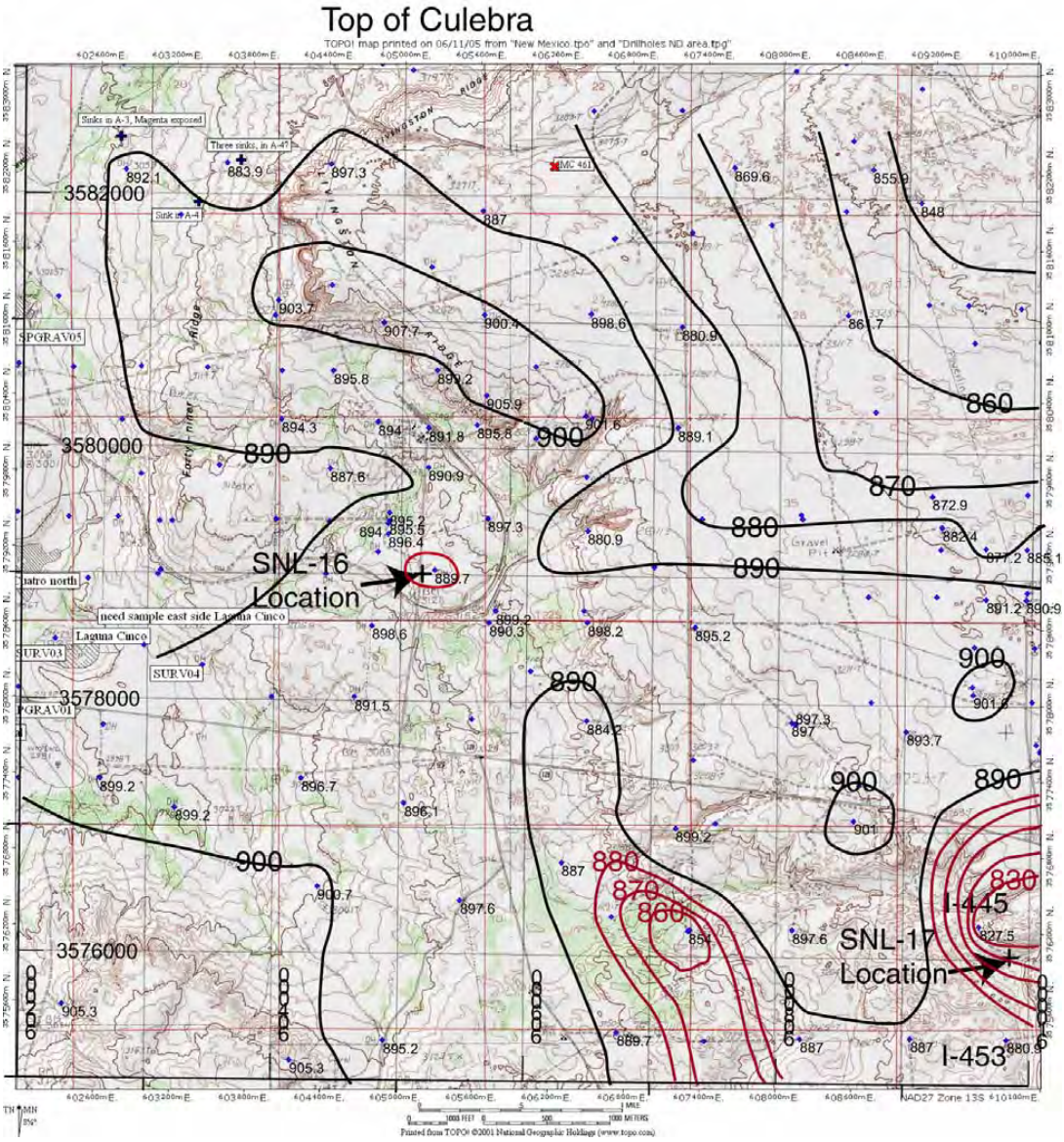


Figure 3. Elevation on the top of the Culebra Dolomite Member of the Rustler Formation in the vicinity of proposed locations for SNL-16 and SNL-17. Units are meters above mean sea level. Red contour lines indicate areas of elevation depressions or probable depressions.

Dennis W. Powers, Ph. D.
Consulting Geologist

Drillhole Locations for FY2006
July 7, 2005

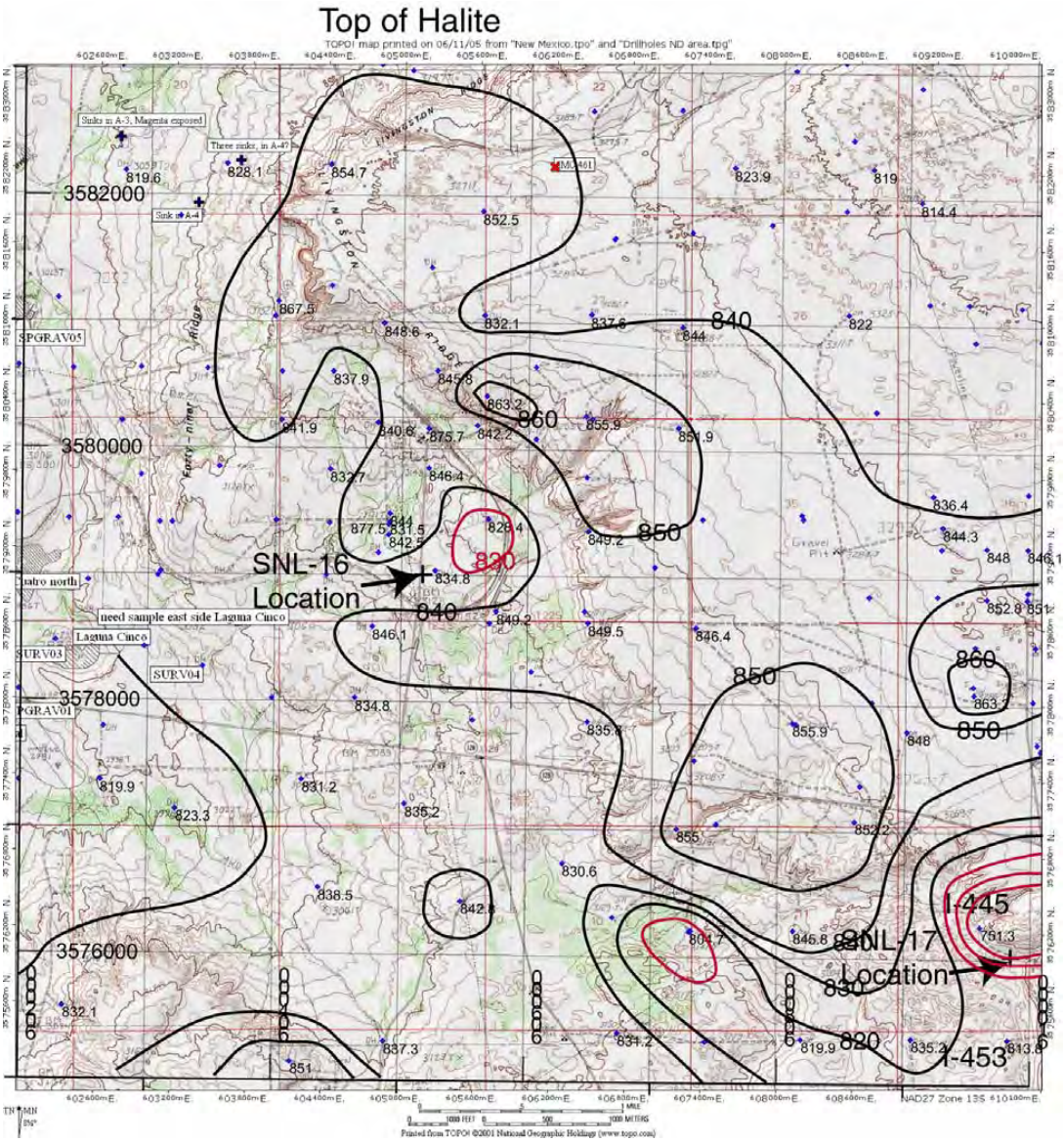


Figure 4. Elevation on uppermost reported halite in drillholes in the vicinity of SNL-16 and SNL-17 proposed locations. Red contour lines indicate areas of elevation depressions or probable depressions. Halite has been reported within the lower Rustler in some drillholes east of Livingston Ridge, and a high location west of Livingston Ridge around the Nash Draw mine facilities may be a remnant of Rustler halite because the elevation is relatively close to the Culebra (Figure 3). Units are meters above mean sea level.

Appendix B
Abridged Borehole History

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

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

4-7-06 WTWWS crew moved equipment from yard to SNL-16 site and set up rig.

4-10-06 Safety meeting at Odessa yard. Loaded and moved equipment to SNL-16 site by 10:30. *George Wilcox of Constructors arrived on site 08:00 with backhoe. Will come back after rig is moved to allow mudpit to be dug. Warren Cat Rental (Midland) arrived 10:15 with compressor.* Prepared for drilling. Drilled 17.5" hole to 35' from 14:30 to 15:27 and set surface casing. Lea Land arrived 16:05 with rolloff. Southeast Ready Mix arrived at 16:10. Cemented annulus of casing by 16:50; formed pad around casing. Hauled office trailer from WIPP site and set up. Departed site 17:45.

4-11-06 WTWWS crew arrived on SNL-16 site at 07:15; held safety meeting. *Johnny Wood (Diamond Oil Well Drilling Company) arrived on site for coring.* Rigged up to take 4" core from 35'; began coring at 13:00 with air. Stopped at 45.5' at 14:15. Retrieved core, laid down 10.5'. Ran core barrel into hole and began coring at 15:00. Cut 26.5' by 15:40. Tripped out and finished laying down 26.5' of core by 16:40. Laid down core barrel, picked up bit and reamers and ran into hole. Took diverter to Odessa for repairs. *Secured site and departed at 18:50.*

4-12-06 WTWWS crew arrived on SNL-16 site at 07:15; held safety meeting. Rigged up diverter; began reaming to 11" from 35' at 08:45 with air. Repaired diverter from 09:35 to 09:50. Frac tanks arrived at 11:38. Continued reaming and drilling to 95' by 14:10. A few gallons of water were blown from hole at 95' after 1 hour observation. Continued drilling with air to 123' *by 13:46.* Set up and began drilling with compressed air and QuikFoam® (used 1 gallon) from 123'. Drilled to 174' (*corrected depth*) at 15:51. Ended drilling, tripped out drill pipe, reamers, and bit by 17:15 to prepare for coring from 174'. *Ran SNL borehole camera into drillhole and observed foam at 162' with water inflow along sides at 107' and above. Set miniTroll in drillhole to observe pressure changes overnight.*

4-13-06 *Arrived on site at 06:40. Measured water level in hole ~122' from top of diverter (2.3' above pad level). Removed miniTroll from hole.* WTWWS arrived 07:15; conducted safety meeting. Started to trip into hole to take 4" core from 174'; completed rig repairs. Began coring at 10:30 with air and mist (QuikFoam®). *Unfiltered grab sample of water from diverter had field specific gravity of ~1.01.* Core barrel jammed at 185' at 10:55. Retrieved barrel, laid down 8.7' of core. Tripped core barrel into hole and began coring at 12:17. Cut 12.3' by 12:50. Tripped

out and recovered 11' of core by 13:25. Tripped core barrel to 197.3' and began coring at 14:10. Stopped coring at 203.8' at 14:35. Tripped out core barrel and laid down 6.5' of core. Tripped core barrel into hole to 203.8' and began coring at 16:00. Stopped coring at 213.8' at 16:30. Tripped out core barrel and laid down 2.6' of core by 16:50. Shut down rig at 17:30. Used 2 gallons QuickFoam®. *Installed miniTroll to 170' below top of surface casing at 17:20. Secured site and departed 17:45.*

4-14-06 *Arrived on site at 06:45.* WTWWS crew arrived on SNL-16 site at 07:00; held safety meeting. *Checked water level with Solinst; readings inconclusive due to foam. Removed miniTroll from well at 07:05.* Tripped core barrel into hole to 213.8' while blowing water from hole. Began coring at 08:10. Stopped coring at 224.3' at 08:30. Tripped out core barrel and laid down 6' of core by 09:24. Shut down rig for weekend. Used 1 gallon QuickFoam®. *Set miniTroll in drillhole by 09:40 to observe pressure changes over weekend.* Departed site at 10:10.

4-17-06 *Arrived on site at 08:00. DOWDCO on site. Removed miniTroll from well at 08:20.* WTWWS crew arrived on SNL-16 site at 09:00. *Checked water level with Solinst; readings inconclusive due to foam.* Tripped core barrel into hole to 224.3' and began coring at 10:40. Stopped coring at 254.3' at 11:15. Tripped out core barrel and laid down 28.6' of core by 11:45. Tripped core barrel into hole to 254.3' and began coring at 13:20. Stopped coring at 284.3' at 14:15. Tripped out and laid down 6' of core. Tripped into the hole to 284.3' and began coring at 16:00. Stopped coring at 299.3' at 16:25. Tripped out of hole with core barrel and recovered 0.5' of core. Ended coring of SNL-16. Broke down core barrel and released DOWDCO at 17:30. Used 2 gallons of QuickFoam®. *Set miniTroll at 170' in drillhole by 17:05 to observe pressure changes overnight. Departed site at 18:30.*

4-18-06 *Arrived on site at 06:40. Removed mini-Troll from well by 07:00 and measured water level at 123.1' below top of diverter. Took ~1 gallon water sample.* WTWWS tripped into hole by 08:50 and found ~5' of fill. Circulated hole and tripped out by 09:20. JetWest arrived at 10:20 and set up to log SNL-16. Logging complete by 12:15. Ordered cement and began to trip into hole to cement bottom back to 225' to 234'. Cement truck arrived at 14:00 and pumped 7/8 cubic yard into bottom of drillhole by 15:00. Cleaned and tripped out drillpipe and shut down by 16:00.

4-19-06 *Arrived on site at 06:40.* WTWWS crew arrived on SNL-16 site at 07:00; held safety meeting. Tripped into hole and tagged cement at 239'. Added two bags of bentonite to bring plug to 232'. Tripped into hole with bit and reamers and started reaming to 11" from 174' at 09:00. Completed reaming to 228' by 10:45. Used 1 gallon of QuickFoam®. Tripped out and laid down drill pipe and bit by 11:30. Rigged up and ran tremmie into hole by 13:15. Started running casing with centralizers into hole at 13:45 and finished by 14:45. Pumped 20 bags of 4/10 sand into hole and tagged at 187'. Placed 4 bags of bentonite over sand pack to bring to 182'. Mike Stapleton (Office of State Engineer) on site to observe cementing. Began pumping cement at 16:50 and pumped 4 cubic yards (108 sacks) with returns to surface by 17:35. Pulled tremmie and cleaned up. Departed site at 18:00.

4-20-06 Arrived on site 07:00. Rigged down and moved to SNL-17. Departed site 18:15.

4-25-06 *Met with Doug Shields and got pump and pipe trailer. Arrived at SNL-16 site at 09:15. Started in well at 09:50 with pipe and jet tool. Jet tool installed: started installing plumbing to frac tank at 10:20. Chaparrel Services, Eunice, NM, arrives at 12:15 with 100 barrels of potable water from Eunice city water supply. Ready for jetting at 100-120 psi at 12:50. Used~10 barrels by 13:20 with no return to surface. Pumped 30 barrels by 13:35 without return to surface. Pumped 80 barrels by 14:15 with no return to surface. Finished jetting at 14:35 with no returns to surface. Pulled pipe and tool from drillhole. Began installing 3 hp pump to ~214.1' at 15:25. Tested pump; produced 14-15 gpm. Turned off for night.*

4-26-06 *Arrived on site at 08:00. Water level measured 123.50' below top of casing. 016746.5 meter reading at start. Started pump at 08:30 with flow rate 13.75-14 gpm. Specific gravity 1.005, temperature 19.1°C. Flow rate 14 gpm, specific gravity 1.005, temperature 20.5°C, water level 125' at 09:00. Water clear. Time, flow rate, specific gravity, water level as follows:*

09:30: 14 gpm, 1.005, 21.2°C, 125.6';
10:00: 14 gpm, 1.006, 21.8°C, 125.65';
11:00: 14 gpm, 1.007, 22.1°C, 125.71';
12:00: 14 gpm, 1.007, 22.3°C, 125.75';
13:30: 14 gpm, 1.008, 23.1°C, 125.81';
14:40: 14 gpm, 1.008, 23.6°C, 125.82';
16:00: 14 gpm, 1.009, 23.6°C, 125.82';
17:30: 14 gpm, 1.009, 23.6°C, 125.83';
18:00: Turned pump off; well development finished.

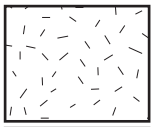
Appendix C
Geologic Logs

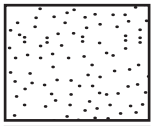
Note: The original field descriptions and graphic logs were prepared at differing scales, and the graphic logs for publication were generally produced at 10 or 20 vertical ft per inch, as indicated in the header for the log.

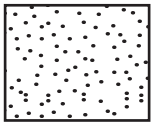
The field descriptions were related to depth based on drilling information and core recovery as best determined in the field. Core and sample footages are marked accordingly and can vary somewhat from depths determined for stratigraphic units based on geophysical logs (see Table 2-1 of text). Core depth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

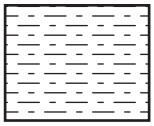
Explanation of Symbols Used in Lithologic Logs (Appendix C)

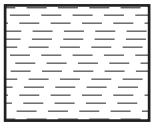
Lithology

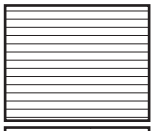

Construction fill

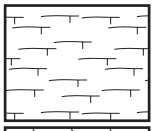

Fine sand or sandstone

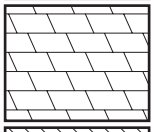

Medium or coarse sand or sandstone

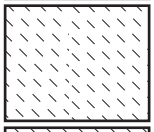

Siltstone

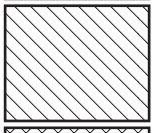

Claystone

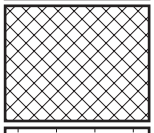

Organic-rich, claystone

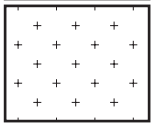

Carbonate (pedogenic calcrete)


Dolomite


Gypsum


Anhydrite


Polyhalite


Halite

Features


Cross-cutting strata


Ripples


Bioturbation

Stylolite


Wavy bedding


Stromatolites, algal bedding

Vertical gypsum crystals


Gypsum nodules


Clasts, may show lithology as fill pattern


Brecciated, fractures

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

Erosional boundary

Sharp lithologic contact


Gradational lithologic contacts

hz Hard-drilling zone

sl Slickensides

ns No cuttings sample

Symbols may be combined; not all symbols may be used

CORE LOG Sheet 1 of 5

Hole ID: SNL-16 Location: SE 1/4, section 33, T22S, R30E, Eddy Co, NM

Drill Date: 4/10/2006
Drill Crew: West Texas Water Well Service
Drill Method: Rotary with air
Hole Diameter: initial 11 inches
Hole Depth:
Hole Orient: vertical downward
Drill Make/Model: Gardner-Denver 1500
Barrel Specs: 6 in o.d., 4 in. core
Drill Fluid: air
Core Preserv: box as is

Logged by: Dennis W. Powers, Ph.D., consulting geologist Date: 4/10/2006 Scale: variable

NAD27	Northing UTM (m)	Easting UTM (m)	Elevation
Survey Coordinate: ±5m	3578997	605191	3130 ft amsl

Comments: Field UTM coordinates based on GPS unit. See survey plat in text.
Note: Core depths for Run 1 & 2 were marked 1.5' deeper than true depth. Depths reported here are revised. Cores were not remarked.

Run Number	Depth ( )	% Recovered	RQD	Profile (Rock Type)	Description	Remarks
					See note above re depths and core markings.	all times MDT begin with air 1331 MDT
N/A	0	N/A	N/A		Pad fill and sand (5YR5/6); fine, subround, poor-medium sorting; surface sand; friable to unconsolidated	17.5 inch hole for 12.75" casing
			C1(5')		2-6' Sand (5YR6/8); very fine to medium; round to subround; friable to slightly lithified, calcareous	
			C2(8')		6'	
					6-10' Mescalero caliche, sandy limestone; white, moderately lithified; grains subround to round	
	10		C3(10')		10'	
					10' Top of Gatuña Formation	
					Sandstone, white to pink (5YR8/3); grains subround to round; 5% dark grains; moderately lithified.	
					15' Sandstone to small pebble conglomerate (5YR5/4); dark chert to 0.2"; moderately lithified, calcareous.	
	20		C4(20')		20' Siltstone, light red (2.5YR6/8), sandy, poor to moderate lithification	
			C5(25')		25' Siltstone, red (2.5YR5/8), poor to moderate lithification;	
					30' Dark red siltstone, better lithified than above	
	30		C6(30')		35' siltstone and gypsum	
35						35' end drilling 1427 to set surface casing
1	40	10.5' cut, recovered 10.5' (100%)	1.5' in segments <4"; RQD= 85.7		36-37' Magenta clasts and red siltstone with gypsum veins	4/11/06 begin coring at 35' at 1200 MDT. Hole dry
					37-42.9' Gypsum, white, with weak red banding; stylolites with 1/2" relief at 42.8', 41.9', 40.4', 40'; possible gypsum growth structures between laminae at ~37.1-37.8'; fracture at 40.6' at 70 degrees, no fill.	
45.5					37.6'	
					Base of Gatuña Formation	
					Top of Magenta Dolomite (Rustler Formation)	
					44.4'	
2					42.9-50.0' Dolomite, weak red (2.5YR5/2) and gypsum, white; banded to laminar, with small relief stylolites (<1/4") following wavy bedding, fracture at 44.2' at ~ 70 degrees from horizontal; no fill	
	50					

Hole ID: SNL-16 CORE LOG (cont. sheet) Sheet 2 of 5

Logged by: Dennis W. Powers, Ph.D. Date: 4/11/06 - 4/12/06

Run Number	Depth (ft)	% Recovered	RQD	Profile (Rock Type)	Description	Remarks
					See note Sheet 1 re depths and core markings.	
2	50	cut 26.5', recovered 26.5' basal 5" broken removing from catcher	~1' in segments <4"; RQD = 96.2; breaks at 60.5-60.9, 63.5.0-64.4; 71.5-71.3'	fg, fg, fg, fg, f	50.0-51.0' White nodular gypsum in weak red dolomite. 64.5-68.5' Horizontal to subhorizontal separations with vertical, fibrous gypsum; small gypsum grains in wavy to laminar beds. fg 62.7-62.9' Subvertical with horizontal gypsum fibers fg 61.8-62.0' shows red stain, pores; might be vug; small (1/8") pores at 63.3' fg 63.8' is double, width 1/4" and 3/8"; clear fibrous gypsum is horizontal with slight sigmoidal shape. f 64.5-64.9' is ~70 degrees from horizontal, stepped, not weathered, no indication of significant solution enlargement; no fill; sides fit tight. high angle fresh breaks 70.5-71.0', probably from core coming out of barrel. mostly gypsum 48.6-50.0', 51.1-52.7', 53.3-54.8', 56.3-57.2', 59.5-60.0'	
	60					
	70					broken at bottom of core by core catcher
		C8			76 Base of Magenta Dolomite Top of Tamarisk	reamed 11" hole from 35-73' 4/12/06 No water in hole to 73'; began drilling 73' at 1010
	80	C9			gypsum, white, fine to very coarse and clear	
	90	ns				few gallons (<5) blown from hole at 95' after 1 hr shut down.
	100	ns			Video shows high angle fracture and small (~1/2"?) openings with small water flow at 97'.	
	110	C10				
	120	C11				end drilling with air only. 123' began drilling with QuikFoam® and compressed air.
	130	C12				

Hole ID: SNL-16 CORE LOG (cont. sheet) Sheet 3 of 5

Logged by: Dennis W. Powers, Ph.D. Date: 4/12/06

Run Number	Depth (ft)	% Recovered	RQD	Profile (Rock Type)	Description	Remarks
N/A	130	N/A	N/A		Gypsum, white to gray, with clear crystals up to 1/2" in mostly fine gypsum.	drilling with air and QuikFoam®
	140					
	150					
	160					
	170					end drilling at 174' at 1615; ran SNL camera in hole - foam at 162'; water at 107' and above seeping into hole; set miniTroll.
3	180	cut 11', recovered 8.6'	8' in segments >4"; RQD = 93.0		168' 168-176.5' Claystone and siltstone 176.5-185' Mudstone, dark reddish brown (2.5YR 3/4) with angular to subangular clasts of laminated medium to dark gray (2.5YRN5-6) siltstone from 1/4-3" length, and angular to subrounded clasts of lighter brown or red (2.5YR5/8) siltstone up to 1/2" diameter. Includes angular to subround blocks of gypsum 3-4" at base, 1/2-1.5" upward. Low angle (<40 degrees from horizontal) fractures with gypsum fill are common in upper 4'. No apparent bedding. Clasts float in matrix.	4/13/06 Solinst response at 119.7' at 0605. Retrieved miniTroll.
4	190	cut 12.3', recovered 11'	~7' in segments >4"; RQD = 63.6 not whole		185' 185-190.6' Gypsum, white to gray, laminae to thinly bedded gypsum from base to 188.5'. Very coarse crystalline gypsum (may exceed 4" crystal size) at 188'. Fracture at 190' with clay infill. Corroded surface 188-189' with infill clasts and silty claystone (2.5YR4/4). Silty claystone at 186.5-186.8'. Gray siltstone at 185.5'. Upper surface brecciated. 190.6' 190.6-215.3' Dolomite, brown to pale brown (10YR5/3 - 6/3, damp) from 190.6-~194', light gray (10YR7/2) below 194'. Very thin dark laminae above 194', probably more organic-rich. High density of intersecting fractures but no visible displacement. From 194-197', fractures are more blocky, slight to moderate staining, poor strength, rare visible vugs. Fractures 197.3-203.8' show slight yellowish brown stain. Fractures tend to show tiny curving fractures along zone rather than single sharp fracture in some zones (see 199'). Below 203.8', vugs are rare, large, open. Culebra is fine dolomite, little or no gypsum, laminar, some small pinhole vugs.	Catch sample from diverter has specific gravity = ~1.01, unfiltered; mixed inflow and water used to clean hole (<10 gal poured in hole). Core 3 - may have left core from base in hole; marked core from top. end coring at 197.3' on 4/13/06
5	200	cut 6.5', recovered 6.5'	3.25' in sgmts >4"; RQD = 50.0			Begin coring from 197.3' 4/14/08
6	210	cut 10.0', recovered 2.6'	~0.6' in sgmts >4"; RQD = 23.1			Core loss in run 6 unassigned; depths not marked.

Hole ID: SNL-16 CORE LOG (cont. sheet) Sheet 4 of 5

Logged by: Dennis W. Powers, Ph.D. Date: 4/13/06-4/14/06; 4/17/06

Run Number	Depth (ft)	% Recovered	RQD	Profile (Rock Type)	Description	Remarks
6	210				213.8-215.3' Dolomite, white (2.5Y8/2), fine grained; thin subhorizontal laminae; small subvertical fracture, with some open porosity, not open at macroscopic level; deformed lower 0.5', bedding inclined to ~30 degrees; sharp basal contact.	end coring at 213.8'; install miniTroll 170' at 1620 MDT 4/13/06
7	220	cut 10.5', recovered 6.0'	~0.6' in segments <4". RQD = 90	assumed as core loss zone	215.3 Base of Culebra Dolomite Top of Los Medaños 215.3-215.8' Silty claystone, dark gray (5Y4/1); laminar bedding, deformed at upper contact; slickensides at multiple orientations, more abundant ~ horizontal. 215.8-217.6' Siltstone, sandy, argillaceous, gray (5Y6/1), mottled; fine subhorizontal laminae and crosslaminae, with lighter clasts or (?) subhorizontal bioturbation that has been flattened; small sets show some erosion at base; thin gypsum at 216.7', 217.5'; larger fg at 216.7' at 70 degrees; smaller (~1") blocky fractures, no displacement.	Removed miniTroll at 0605 MDT 4/14/06 Solinst signal ~120' not conclusive. Ran drill pipe to 120' and blew water. Installed miniTroll at 170' at 0840 MDT
8	230	cut 30', recovered 28.6'	0.2' in segments <4"; RQD = 99.3		226.2 217.6-219'+ Claystone, silty, dark reddish brown (2.5YR4/4) with gray siltstone clasts (rounded) near top; subhorizontal laminar bedding; small gypsum clasts, bedding, along with gypsum fibers along subhorizontal separations. Some subhorizontal slickensides 224.3-226.2' Silty claystone, red (2.5YR4/6) with small (<1/2") clasts of silty claystone slightly darker red; some small gypsum clasts/breccia at base. Coarse pebbles at top may or may not be in place. Bedding indistinct; vertical fg at 225-225.7'. Horizontal separations with fibrous gypsum at 225.2', 225.7', 226'.	4/17/06 miniTroll removed at 0720 MDT; sounding at 110.5'- may not be true water level.
	240				239 245.8 226.2-239.0' Gypsum, white to light gray, laminated, with small (~1/8" high) gypsum growth at 237.6-237.9', 236.7-236.0', 235.8-235.5', 235.3-234.3', 229.5-229', and possibly other intervals. Laminae couplet (light-dark) from ~1/16" to ~1/4". Some small elongate pores on surface along bedding. Wavy bedding 235.4-236', truncates bedding at 235.9'. Basal bedding distorted to wavy. fg at 233.6-235.0' is vertical, 1/4" wide truncated at base in zone of coarse gypsum.	Core run 8, assigned loss to base; sand oozed out of barrel.
	250				249.3 239.0-245.8' Claystone, silty, red (2.5YR5/6) at base, with gray siltstone clasts and gypsum. Bedding faint. Gypsum subhorizontal, as small crystals. Siltstone washed out in local areas; becomes siltier upwards and chroma changes to weak red (2.5YR5/2). Gypsum increasing upward from 241.8'. Gray siltstone from 239.6' to base of gypsum. Possible smeared intraclasts 241.6-243.0'.	assumed core loss mainly at top of core run 9.
9	260	cut 30', recovered 6.0'	1' in segments <4". RQD = 83.3	No core recovery	245.8-249.3' Gypsum, white to reddish (near base); fine to thick laminae; some coarse (up to 1") clear gypsum in vuggy zones in upper 2', some pack breccia possible. Sharp basal contact. 249.3-253.0' Sandy siltstone, red (2.5YR5/6), argillaceous; includes small clasts of slightly darker red siltstone and some gray siltstone; some fine laminae, contorted; some zones lack discernible bedding. Gypsum ranges from fine clasts to some selenite.	
	270				278.3-284.3' Sandstone, silty, dark reddish brown (2.5YR5/6) to olive gray (5Y4/2); thin laminae mainly horizontal; block at 282.2-283.2' dips ~80 degrees, parts along bedding (not fracture). Gypsiferous in more lithified zones, possible poikilotopic crystals. Clasts 278.3- 279.3'; some slight cross-cutting bedding 281.6-282'.	grab sample fluid blown from well at 284' has field specific gravity ~1.08
	280				284.3 Pockmarked surface 280-280.5' from washout of siltstone (gray). Stellate to displacive gypsum 280.5-281.5'.	
10	290			No core recovery		

Hole ID: SNL-16 CORE LOG (cont. sheet) Sheet 5 of 5

Logged by: Dennis W. Powers, Ph.D. Date: 4/17/06

Run Number	Depth (ft)	% Recovered	RQD	Profile (Rock Type)	Description	Remarks
	290	cut 15'; recovered 0.5', plus watery sand	RQD = 0, no recovered segments >4"			
	300				299.3' Gray sandstone.	end drilling 299.3' on 4/17/06 installed miniTroll to 170' below casing at ~16:05 MDT

Appendix D
Permitting and Completion Information

A case file for SNL-16 (C-3220) containing official documents is maintained by the land management coordinator, Environmental Monitoring and Hydrology Section of Washington Regulatory and Environmental Services, for the WIPP Project. Selected documents are reproduced here for ease of access. Originals have been reduced to fit page formats.

As noted in the text, all official correspondence concerning permitting and regulatory matters should refer to the New Mexico State Engineer permit number C-3220.

Well-drilling wastes for SNL-16 were characterized and disposed of at Lea Landfill.

Dennis W. Powers, Ph. D.
Consulting Geologist

April 23, 2006

Ron Richardson
Field Lead
WRES

Rick Beauheim
Hydrology Lead
Sandia National Laboratories

Re: Screen Interval for Culebra Dolomite Member in SNL-16

The information available after geophysical logging on April 18, 2006, indicates that the best interval to screen the Culebra in SNL-16 is from 216.0–189.85 ft below the top of the surface conductor casing (see figure).

These are factors considered in this decision for SNL-16:

- The Culebra interval, based on the natural gamma log, is from 217–193 ft. The Culebra is 24 ft thick, about average around the WIPP site. Coring indicated 24.7 ft of Culebra, as marked at top and bottom, but there were intervals without core recovery.
- The gray silty claystone immediately below the Culebra was moderately indurated to somewhat plastic, showing fine laminae and some deformation. Bedding at the top was inclined at ~30º from horizontal, although dolomite slightly higher was ~ horizontal. No salt was encountered in M-2. Small scale cross-laminae are preserved as well as small, mottled siltstone that may be bioturbation or slightly flattened clasts. Near the base of the recovered core from M-2 is a near-vertical, 1 ft-long fracture filled with fibrous gypsum.
- Coring was attempted to 299.3 ft to obtain information about the middle and lower Los Medaños Member, but recovery was very poor below A-1 and a smaller sulfate bed below A-1. A fine sand slurry ran out of the barrel on the last coring attempt. As a consequence, I requested that coring and drilling cease at 299.3 ft to preserve the hole and complete it successfully.
- I recommended cementing back to a depth between 225–234 ft, with a maximum acceptable depth of 240 ft. I recommended using Baroid HolePlug® as necessary to bring the plugged depth higher up into A-1. The cement placed on April 18, 2006, was tagged at 239 ft on April 19, 2006, and HolePlug® was placed to a depth of about 232 ft. I recommended reaming the drillhole to a diameter of 11 inches from 174 ft to a depth of ~228 ft to allow for adding a 6.6-ft-long blank below the screen casing joint.
- The base of the screen interval was raised approximately 1 ft above the claystone (to 216 ft) to minimize squeezing into the screen. The screened or slotted section of the casing joint is 26.15 ft long. The screened interval (to 189.85 ft) will incorporate all of the Culebra and part of the basal Tamarisk anhydrite (A-2). A-2 is likely somewhat porous around coarse gypsum crystals and silt infilling of zones intersected in the core. The sand/gravel pack was recommended to fill to a depth of 187 ft below the top of the conductor casing, with an additional 5 ft of bentonite seal to 182 ft. The annulus was to be cemented from the top of the HolePlug® at 182 ft to the surface.

I believe this letter summarizes the hydrological and geological justification for setting the screened interval and preparing SNL-16 for completion.

Sincerely,

Dennis W Powers

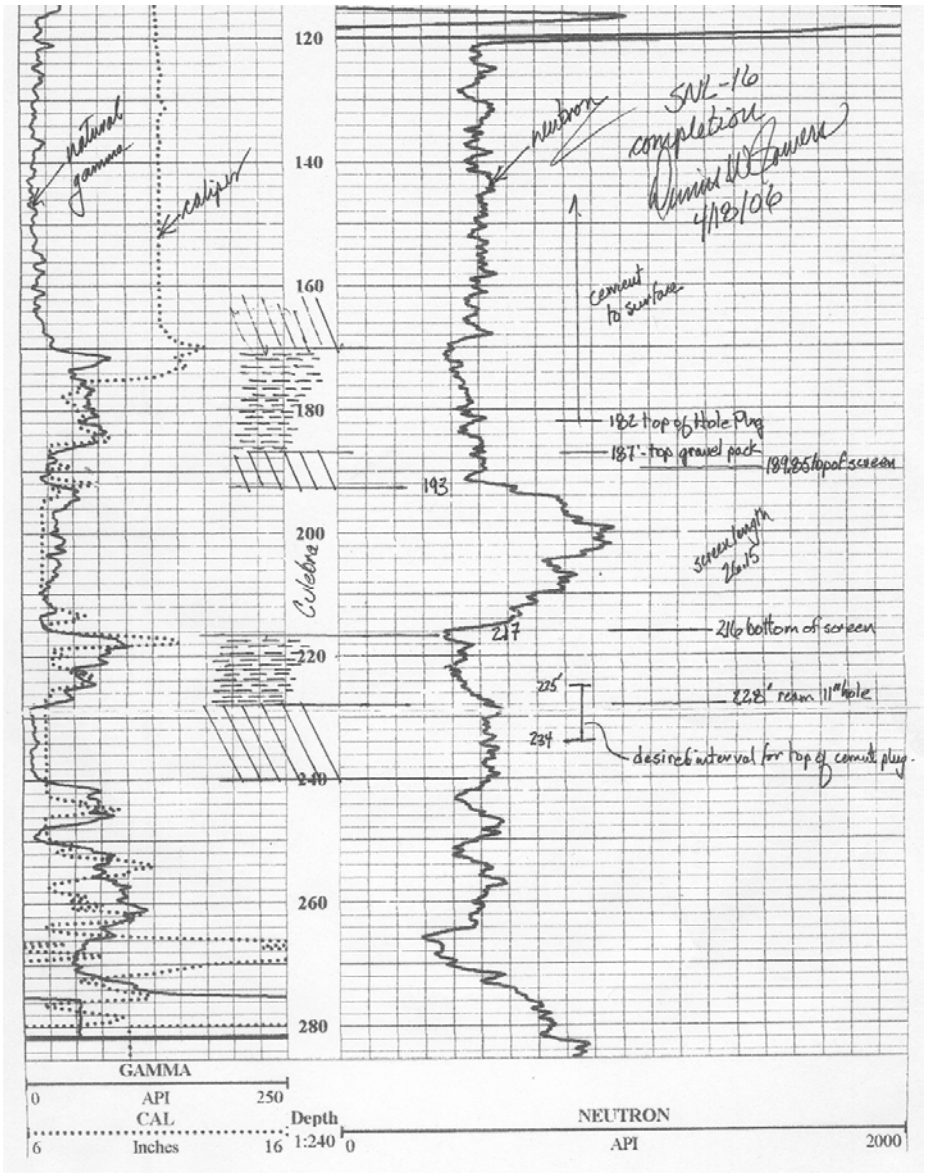
Dennis W. Powers

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

Dennis W. Powers, Ph. D.
Consulting Geologist

April 23, 2006

Partial Geophysical Log of SNL-16
Showing Completion Intervals
(scanned copy of field—marked log)



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

Dennis W. Powers, Ph. D.
Consulting Geologist

April 23, 2006

Rey Carrasco
Geotechnical Engineering
Washington TRU Solutions
Carlsbad, NM 88220

Storage and Retention of Cores and Rock Samples from SNL-16

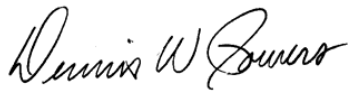
Background
Cores and cutting samples have been collected from drillhole SNL-16 in support of the drilling and testing program to investigate the hydrology of the Culebra Dolomite Member of the Rustler Formation as well as other units of hydrogeological significance to the program. These samples were collected under my supervision, and the chain-of-custody has been maintained by me or WRES personnel. SNL-16 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-16 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-16 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-16 be maintained indefinitely under normal storage conditions because of their relevance to hydrology and monitoring programs. The cores can be accessed for observations, and they can be removed for further laboratory study, including possible destruction, under a plan with appropriate management and QA approval.

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

Supplemental Information
Descriptive core logs and digital photographs of cores with a photograph log will be provided to you on CD-ROM format in accessible formats when the content has been reviewed for the basic data report for SNL-16.



Dennis W. Powers

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

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

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

COPY

Roswell Office
1900 WEST SECOND STREET
ROSWELL, NM 88201

STATE OF NEW MEXICO
OFFICE OF THE STATE ENGINEER

Trn Nbr: 337480
File Nbr: C 03220

July 26, 2005

SNL 16

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

Greetings:

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

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

This permit will expire on or before 07/31/07, unless the well has been drilled and the well log filed in this office.

Sincerely,

Mike Stapleton
(505)622-6521

Enclosure

cc: Santa Fe Office

explore

UNIQUE #	DOE UFC	DATE RECVD	ADDRESSEES
502868	548700	JUL 28 2005	H Johnson w/orig to T. Pfeifer

NEW MEXICO STATE ENGINEER OFFICE
PERMIT TO EXPLORE

SPECIFIC CONDITIONS OF APPROVAL

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

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

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

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

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

LOG The Point of Diversion C 03220 EXPLORE must be completed and the Well Log filed on or before 07/31/2006.

ACTION OF STATE ENGINEER

Notice of Intention Rcvd:	Date Rcvd. Corrected:
Formal Application Rcvd: 07/25/2005	Pub. of Notice Ordered:
Date Returned - Correction:	Affidavit of Pub. Filed:

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

Witness my hand and seal this 26 day of Jul A.D., 2005

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

By: _____
Art Mason

Trn Desc: C 03220 MONITORING WELL

File Number: C 03220
Trn Number: 337480

page: 1

IMPORTANT - READ INSTRUCTIONS ON BACK BEFORE FILLING OUT THIS FORM

APPLICATION FOR PERMIT

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

Date Received 7/25/05 File No. C-3220 Explore

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/Dolomite (Artesian or shallow water aquifer), located in Carlsbad, (Name of underground basin)

3. The well is to be located in the NW ¼ SW ¼ SE ¼ Section 33 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, Waste Isolation Pilot Plant

4. Description of well: name of driller West Texas Water Well Service,
   Outside Diameter of casing < 7 inches; Approximate depth to be drilled 350 feet;

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

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

Subdivision	Section	Township	Range	Acres	Owner

7. Additional statements or explanations The intent of this application is to provide authorization to configure a well to access the Culebra Dolomite member of the Rustler Formation (~350' bgs) for monitoring purposes only. This well will be configured with 5.5" fiberglass casing and a well screen (@ ~250' ft. bgs). See attached justification (well bore entitled SNL 16).

ACTION OF STATE ENGINEER

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

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

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

Witness my hand and seal this 26th day of July, A.D., 2005

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

COPY

Washington
TRU Solutions LLC

WRES:06:003
UFC:5486.00

January 10, 2006

Mr. H. E. Johnson, NEPA Compliance Manager
Carlsbad Field Office
U.S. Department of Energy
P.O. Box 3090
Carlsbad, NM 88221-3090

Subject: BLM RIGHT-OF-WAY GRANT; SNL-16 AND SNL-17

Dear Mr. Johnson:

Attached is the fully executed Right-of-Way Grant for drill locations SNL-16 and SNL-17 issued by the Bureau of Land Management on December 21, 2005. Please contact Mr. Gene Valett at Extension 8261 if this matter requires further discussion.

Sincerely,

D. T. Bignell, Manager
Regulatory Compliance

GLV:llp

Enclosure

cc: V. Daub, CBFO
L. Piper, CBFO

UNIQUE	DOE UFC	DATE RECVD	ADDRESSEES
D60006	5486.00	JAN 10 2006	H Johnson V Daub L Piper

P.O. Box 2078 • Carlsbad, New Mexico USA 88221-2078
Phone: (505) 234-7200 • Fax: (505) 234-7083

Mr. H. E. Johnson January 10, 2006 WRES:06:003

bcc: WRES Distribution

R. R. Chavez	ED
S. B. Jones	ED
R. F. Kehrman	ED
S. C. Kouba	ED
R. D. Reeves	ED
R. R. Richardson	ED
R. A. Salness	ED
J. Siegel	ED
G. L. Valett	ED

WTS Distribution

G. J. Johnson	ED
R. D. Raaz	ED

P.O. Box 2078 • Carlsbad, New Mexico USA 88221-2078
Phone: (505) 234-7200 • Fax: (505) 234-7083

FORM 2800-14
(August 1985)

Issuing Office
Carlsbad Field Office

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF LAND MANAGEMENT
RIGHT-OF-WAY GRANT/TEMPORARY USE PERMIT

SERIAL NUMBER: NMNM-108365
Right-of-Way Grant (Formerly R/W Reservation)

1. A right-of-way is hereby granted pursuant to Title V of the Federal Land Policy and Management Acto of October 21, 1976 (90 Stat. 2776; 43 U.S.C. 1761).

2. Nature of Interest:

A. By this instrument, the holder:

U.S. Department of Energy
P.O. Box 3090
Carlsbad, NM 88221-3090

Receives a right to construct, operate, maintain, and terminate two monitoring well sites (SNL-16, SNL-17), as specified in the application submitted October 17, 2005, on public lands described as follows:

SNL-16
T. 22 S., R. 30 E., NMPM
Section 33: SW¼SE¼.
SNL-17
T. 23 S., R. 30 E., NMPM
Section 12: NW¼SE¼.

b. The right-of-way or permit area granted herein is 150' X 150' for each well site more or less. If a site type facility, the facility contains .517 acres, the two sites combined total 1.034 acres.

c. This instrument shall terminate on August 30, 2032 , unless, prior thereto, it is relinquished, abandoned, terminated, or modified pursuant to the terms and conditions of this instrument or of any applicable Federal law or regulation.

d. This instrument may be renewed. If renewed, the right-of-way or permit shall be subject to the regulations existing at the time of renewal and any other terms and conditions that the authorized officer deems necessary to protect the public interest.

e. Notwithstanding the expiration of this instrument or any renewal thereof, early relinquishment, abandonment, or termination, the provisions of this instrument, to the extent applicable, shall continue in effect and shall be binding on the holder, its successors, or assigns, until they have fully satisfied the obligations and/or liabilities accruing herein before or on account of the expiration, or prior termination, of the grant.

3. Rental:

For and in consideration of the rights granted, the holder agrees to pay the Bureau of Land Management fair market value rental as determined by the authorized officer unless specifically exempted from such payment by regulation. Provided, however, that the rental may be adjusted by the authorized officer, whenever necessary, to reflect changes in the fair market rental value as determined by the application of sound business management principles, and so far as practicable and feasible, in accordance with comparable commercial practices.

4. Terms and Conditions:

a. This grant or permit is issued subject to the holder's compliance with all applicable regulations contained in Title 43 Code of Federal Regulations part 2880.

b. Upon grant termination by the authorized officer, all improvements shall be removed from the Federal lands within 90 days, or otherwise disposed of as provided in paragraph (4)(c) or as directed by the authorized officer.

c. The stipulations, plans, maps, or designs set forth in Exhibits A, A-1, and B, dated May 16 2005, attached hereto, are incorporated into and made a part of this grant instrument as fully and effectively as if they were set forth herein in their entirety.

d. Failure of the holder to comply with applicable law or any provision of this right-of-way grant or permit shall constitute grounds for suspension or termination thereof.

e. The holder shall perform all operations in a good and workmanlike manner so as to ensure protection of the environment and the health and safety of the public.

IN WITNESS WHEREOF, The undersigned agrees to the terms and conditions of this right-of-way grant or permit.

(Signature of Holder)

FOR HAROLD JOHNSON; DOE NEPA COMPLIANCE MGR.
(Title)

DECEMBER 20, 2005
(Date)

(Signature of Authorized Officer)

FOR Tony J. Herrell, Field Office Manager
(Title)

DEC 21 2005
(Date)

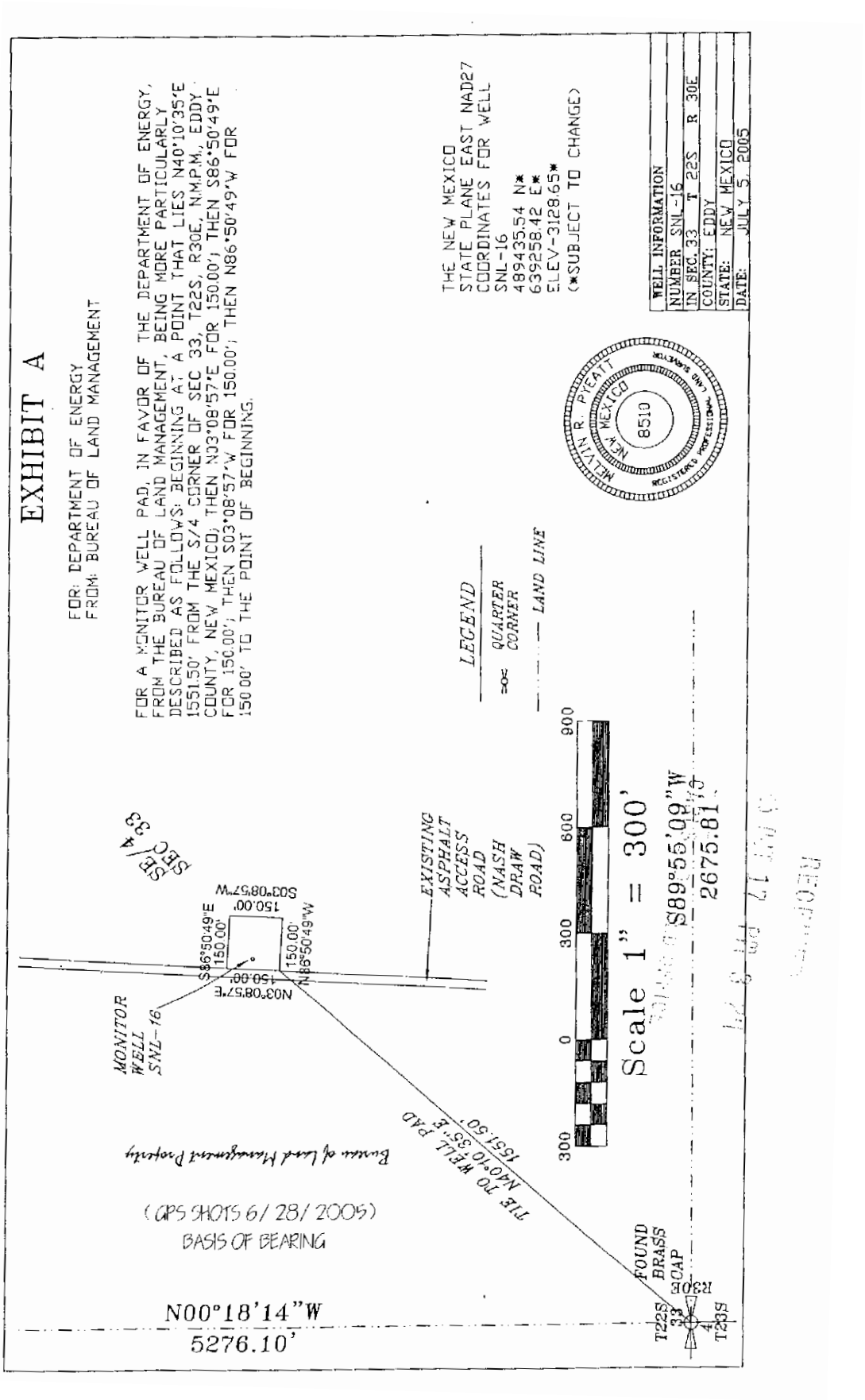


EXHIBIT A
FOR: DEPARTMENT OF ENERGY
FROM: BUREAU OF LAND MANAGEMENT
FOR A MONITOR WELL PAD, IN FAVOR OF THE DEPARTMENT OF ENERGY, FROM THE BUREAU OF LAND MANAGEMENT, BEING MORE PARTICULARLY DESCRIBED AS FOLLOWS: BEGINNING AT A POINT THAT LIES N40°10'35"E 1551.50' FROM THE S/4 CORNER OF SEC 33, T22S, R30E, N.M.P.M., EDDY COUNTY, NEW MEXICO, THEN N03°08'57"E FOR 150.00'; THEN S86°50'49"E FOR 150.00'; THEN S03°08'57"W FOR 150.00'; THEN N86°50'49"W FOR 150.00' TO THE POINT OF BEGINNING.
THE NEW MEXICO STATE PLANE EAST NAD27 COORDINATES FOR WELL SNL-16
489435.54 N*
639258.42 E*
ELEV-3128.65*
(*SUBJECT TO CHANGE)
WELL INFORMATION
NUMBER SNL-16
IN SEC. 33 T 22S R 30E
COUNTY: EDDY
STATE: NEW MEXICO
DATE: JULY 5 2005
MELVIN R. PYEATT NEW MEXICO 8510
LEGEND
QUARTER CORNER
LAND LINE
Scale 1" = 300'
0 300 600 900
300
EXISTING ASPHALT ACCESS ROAD (NASH DRAW ROAD)
SEC 33/4
S03°08'57"W 150.00'
S86°50'49"E 150.00'
150.00' N86°50'49"W
N03°08'57"E 150.00'
MONITOR WELL SNL-16
FILE TO WELL PAD N40°10'35"E 1551.50'
S89°55'09"W 2675.81'
Bureau of Land Management Property
(GPS SHOTS 6/28/2005)
BASIS OF BEARING
N00°18'14"W 5276.10'
FOUND BRASS CAP
R30E
T22S
T23S
33
4

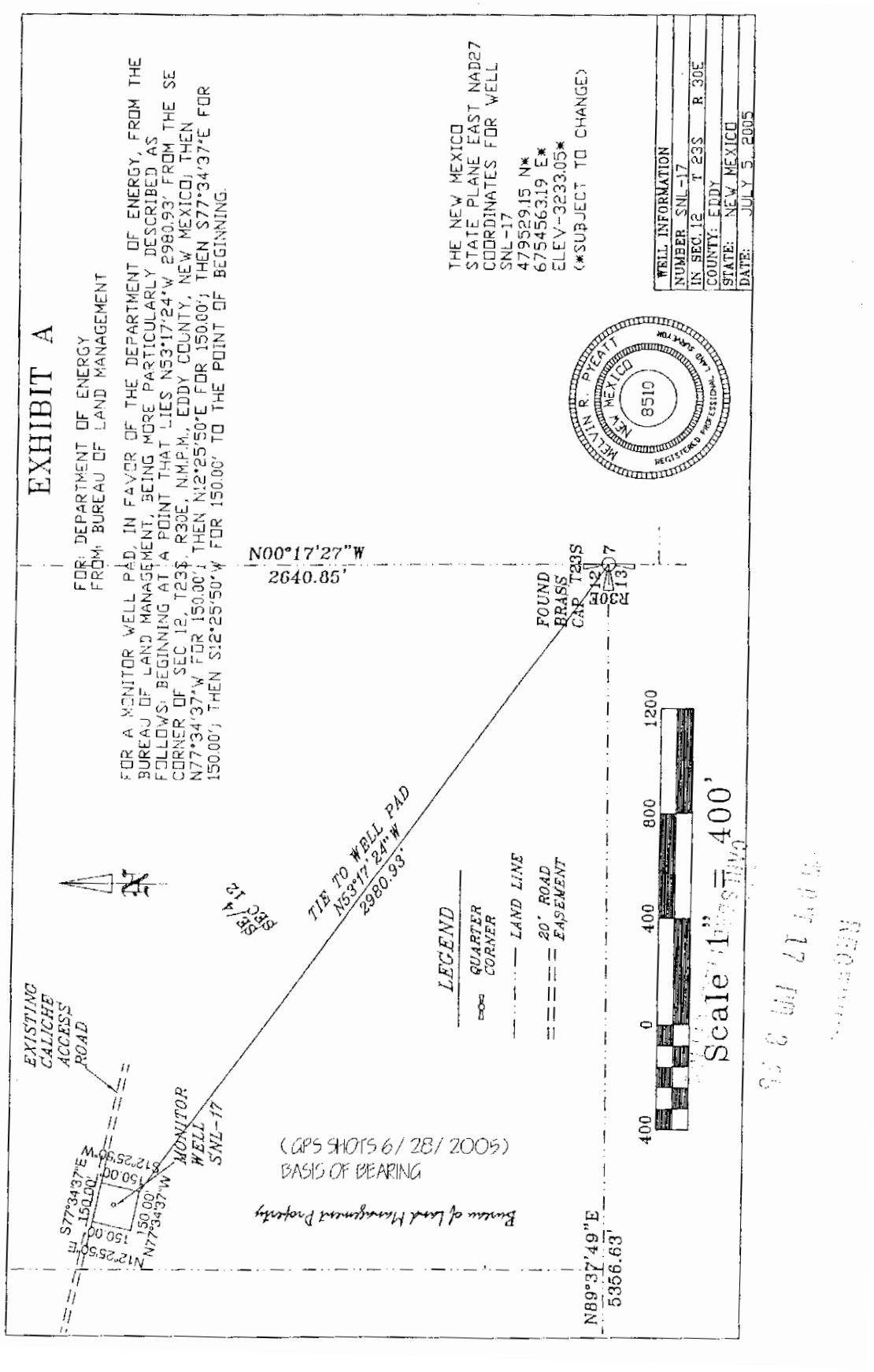


EXHIBIT A
FOR: DEPARTMENT OF ENERGY
FROM: BUREAU OF LAND MANAGEMENT
FOR A MONITOR WELL PAD, IN FAVOR OF THE DEPARTMENT OF ENERGY, FROM THE BUREAU OF LAND MANAGEMENT, BEING MORE PARTICULARLY DESCRIBED AS FOLLOWS: BEGINNING AT A POINT THAT LIES N53°17'24"W 2980.93' FROM THE SE CORNER OF SEC 12, T23S, R30E, N.M.P.M., EDDY COUNTY, NEW MEXICO; THEN N77°34'37"W FOR 150.00'; THEN N12°25'50"E FOR 150.00'; THEN S77°34'37"E FOR 150.00'; THEN S12°25'50"W FOR 150.00' TO THE POINT OF BEGINNING.
THE NEW MEXICO STATE PLANE EAST NAD27 COORDINATES FOR WELL SNL-17
479529.15 N*
675456.19 E*
ELEV-3233.05*
(*SUBJECT TO CHANGE)
WELL INFORMATION
NUMBER SNL-17
IN SEC. 12 T 23S R 30E
COUNTY: EDDY
STATE: NEW MEXICO
DATE: JULY 5, 2005
MELVIN R. PYEATT
NEW MEXICO
8510
REGISTERED PROFESSIONAL LAND SURVEYOR
N00°17'27"W
2640.85'
FOUND BRASS CAP
T23S
R30E
13
TIE TO WELL PAD
N53°17'24"W
2980.93'
EXISTING CALICHE ACCESS ROAD
MONITOR WELL SNL-17
S77°34'37"E
150.00'
N12°25'50"E
150.00'
N77°34'37"W
150.00'
S12°25'50"W
150.00'
LEGEND
QUARTER CORNER
LAND LINE
20' ROAD EASEMENT
(GPS SHOTS 6/28/2005)
BASIS OF BEARING
N89°37'49"E
5356.63'
400
0
400
800
1200
Scale: 1" = 400'

EXHIBIT A-1
December 19, 2005
NM-108365
Department of Energy Monitoring Wells

STIPULATIONS FOR FLPMA SITES

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

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

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

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

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

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

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

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

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

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

Special Stipulations:

1. The Authorized Officer for the BLM, Carlsbad Field Office, will be contacted at (505-234-5972) for full restoration of the monitoring well prior to abandonment.

STATE ENGINEER OFFICE

WELL RECORD

Section 1. GENERAL INFORMATION

(A) Owner of well WASHINGTON TRU SOLUTIONS Owner's Well No. SNL-16
Street or Post Office Address P.O. BOX 2078
City and State CARLSBAD, NEW MEXICO 88221

Well was drilled under Permit No. C-3220 and is located in the:

a. SE ¼ SE ¼ ¼ ¼ of Section 33 Township 22S Range 30E N.M.P.M.

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

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

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

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

Address 3410 MANKINS ODESSA, TEXAS 79764

Drilling Began 4-10-06 Completed 4-19-06 Type tools AIR ROTARY Size of hole 11 in.

Elevation of land surface or _____ at well is 3128 ft. Total depth of well 224 ft.

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

Section 2. PRINCIPAL WATER-BEARING STRATA

Depth in Feet From	Depth in Feet To	Thickness in Feet	Description of Water-Bearing Formation	Estimated Yield (gallons per minute)
84	100	16	WHITE GYPSUM & BROWN CLAY	
193	217	24	LIGHT BROWN DOLOMITE	
			(CULEBRA FORMATION)	

Section 3. RECORD OF CASING

Diameter (inches)	Pounds per foot	Threads per in.	Depth in Feet Top	Depth in Feet Bottom	Length (feet)	Type of Shoe	Perforations From	Perforations To
12-3/4	33.41	WELDED	3' AGL	35	41'			
5-1/2 FIBERGLASS	4.4	4	2-1/2' AGL	224'	226.5'	FIBERGLASSCAP	.070 SCREEN 189.85	216

Section 4. RECORD OF MUDDING AND CEMENTING

Depth in Feet From	Depth in Feet To	Hole Diameter	Sacks of Mud	Cubic Feet of Cement	Method of Placement
0	35	17-1/2		30	TRIMMIE
0	182	11" 5-1/2 CSG		108	TRIMMIE
187	182	11" 5-1/2 CSG	HOLE PLUG 4 BAGS		
287	239	6-3/4		27	

Section 5. PLUGGING RECORD

Plugging Contractor _____
Address _____
Plugging Method _____
Date Well Plugged _____
Plugging approved by:
_____
State Engineer Representative

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

FOR USE OF STATE ENGINEER ONLY

Date Received

Quad _____ FWL _____ FSL _____

File No. _____ Use _____ Location No. _____

Section 6. LOG OF HOLE

Depth in Feet From	Depth in Feet To	Thickness in Feet	Color and Type of Material Encountered
0	2	2	CONSTRUCTION FILL
2	6	4	REDDISH-BROWN SAND, SLIGHTLY CALCAREOUS
6	10	4	WHITE CALICHE & CALCAREOUS SAND (MESCALERO CALICHE)
10	27	17	WHITE TO LIGHT RED CALCAREOUS AND, SANDSTONE & SILTSTONE (GATUNA FORMATION)
27	35	8	WEAK RED TO REDDISH BROWN CALCAREOUS SILTSTONE (MUDSTONE IN MIDDLE OF FORTY-NINER MEMBER OF THE RUSTLER FORMATION)
35	44	9	WHITE GYPSUM WITH WEAK RED BANDING (LOWER FORTY-NINER MEMBER OF THE RUSTLER FORMATION)
44	78	34	WEAK RED DOLOMITE & WHITE GYPSUM (MAGENTA DOLOMITE MEMBER OF THE RUSTLER FORMATION)
78	193	115	WHITE GYPSUM BEDS WITH INTERMEDIATE GRAY TO REDDISH BROWN CLAYSTONE (TAMARISK MEMBER OF THE RUSTLER FORMATION)
193	217	24	LIGHT BROWN DOLOMITE (CULEBRA DOLOMITE MEMBER OF THE RUSTLER FORMATION)
217	228	11	DARK GRAY TO REDDISH BROWN GYPSIFEROUS CLAYSTONE (UPPER LOS MEDANOS MEMBER OF THE RUSTLER FORMATION)
228	240	12	WHITE GYPSUM (UPPER LOS MEDANOS MEMBER OF THE RUSTLER FORMATION)
240	299.3	59.3	REDDISH BROWN MUDSTONE, GRAY SILTSTONE, & GYPSUM (MIDDLE LOS MEDANOS MEMBER OF THE RUSTLER FORMATION)

Section 7. REMARKS AND ADDITIONAL INFORMATION

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

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.

Appendix E
Archeological Clearance Report

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

TITLE PAGE/ABSTRACT/
NEGATIVE SITE REPORT
CFO/RFO

1/03

1. BLM Report No.	2. Reviewer's Initials/Date_____ ACCEPTED ( ) REJECTED ( )	3. NMCRIS No.: 94641

4. Type of Report: Negative (X) Positive ( )

5. Title of Report: Class III archaeological survey of a pad for monitor well No. SNL-16. Author(s): Ann Boone	6. Fieldwork Date(s): from 13 Sept. 2005 to 7. Report Date: 14 Sept 2005
8. Consultant Name & Address: Boone Archaeological Services 2030 North Canal, Carlsbad, NM 88220 Direct Charge: Danny Boone Field Personnel Names: Danny Boone Phone: (505) 885-1352	9. Cultural Resource Permit No.: BLM: 190-2920-05-G STATE: NM 05-157 10. Consultant Report No. BAS 08-05-76
11. Customer Name: Washington TRU Solutions, LLC Responsible Individual: Ron Richardson Address: P.O. Box 2078 Carlsbad, NM 88221 Phone: (505) 234-8395	12. Customer Project No.: SNL-16

13. Land Status:	BLM	STATE	PRIVATE	OTHER	TOTAL
a. Area Surveyed (acres)	1.01 (+/-)	0	0	0	1.01 (+/-)
b. Area of Effect (acres)	0.52 (+/-)	0	0	0	0.52 (+/-)

14. a. Linear: Length; N/A Width; N/A
b. Block: 150' x 150' [Survey,210' x 210'] See. 16 b.

15. Location: (Maps Attached if Negative Survey)
a. State: New Mexico
b. County: Eddy
c. BLM Office: Carlsbad
d. Nearest City or Town: Carlsbad, NM
e. Legal Location: T 22S, R 30E, Sec. 33, SW¼ SE¼.
f. Well Pad Footages: N/A
g. USGS 7.5 Map Name(s) and Code Number(s): REMUDA BASIN, NM (Prov. Ed. 1985) 32103-C8

16. Project Data:

a. Records Search: Date(s) of BLM File Review: 12 Sept. 2005 Name of Reviewer (s): Danny Boone

Date(s) of ARMS Data Review: 12 Sept. 2005 Name of Reviewer (s): Ann Boone

Findings (see Field Office requirements to determine area to be reviewed during records search):

LA 18161 is within 0.25 mile

b. Description of Undertaking:

This project is staked as a 150 by 150 feet square. One addational transect around the outer perimeter was added for the 1.0 acre minimum. Access will be from Eddy County Road No. 749 which is the western boundary of the survey area. A plat for the project is attached to this report.

c. Environmental Setting (NRCS soil designation; vegetative community; etc.):

Topography: Slight westerly sloping sandy plain.

Vegetation: Overall groundcover is approximately 30% consisting primarily of mesquite, broom snakeweed, feather dalai, yucca cactus, assorted grasses and other flora.

NRCS: Simona-Pajarito association: Sandy, deep soils and soils that are shallow to caliche; from wind-worked deposits.

d. Field Methods: (transect intervals; crew size; time in field, etc.):

Transects: A parallel grid spaced 15 meters or less apart.

Crew Size: One

Time in Field: 1.0 hour.

e. Artifacts Collected (?): None

17. Cultural Resource Findings:

a. Identification and description: None

b. Evaluation of significance of Each Resource: None

18. Management Summary (Recommendations):

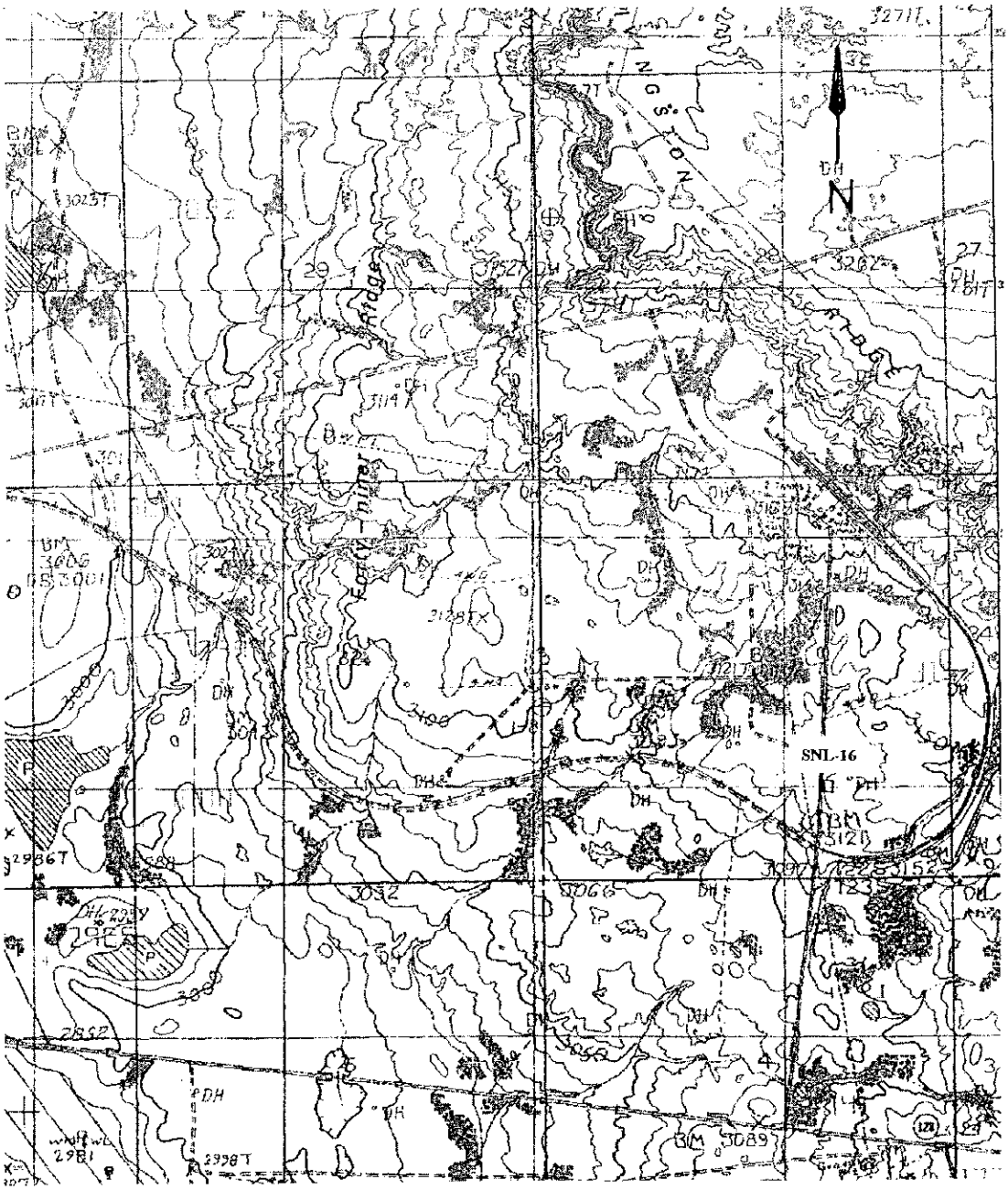
Archaeological clearance of a pad for monitor well No. SNL-16 for Washington TRU Solutions, LLC as presently staked is recommended. If cultural resources are encountered at any time all activity should cease and the BLM Archaeologist notified immediately.

19.

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

Responsible Archaeologist Danny Boone 14 September, 2005

Signature Date



Location Map of a pad for monitor well SNL-16 for Washington TRU Solutions LLC in Section 33, T 22S, R 30E, NMPM, Eddy County, NM.
Map Reference: USGS 7.5' Series; Remuda Basin, NM (Prov. Ed. 1985) 32103-C8

SCALE 1:24000

1 0 1 MILE

1000 0 1000 2000 3000 4000 5000 6000 7000 FEET

1 .5 0 1 KILOMETER

Appendix F
Photograph Logs

Digital photographs were taken of the cores from SNL-16. These photographs have been compiled into a listing of consecutive photos beginning with the uppermost core (Gatuña Formation) and ending with the lowermost (upper Los Medaños Member of the Rustler Formation). The photographs were taken in the field shortly after recovery. A CD-ROM with these images (jpeg format) is being archived, and a copy with photographic log is maintained by Geotechnical Engineering (Washington TRU Solutions LLC) with records of the cores stored for WIPP.

File	DATE	LOCATION	DESCRIPTION OF SUBJECT (includes individual/group names, direction, etc. as appropriate)	PHOTOGRAPHER (initials and dept.)
SNL-16_Core001.jpg	4-11-06	SNL-16 drillpad; T22S, R30E, sec 33	Close-up photo of Gatuna Formation core, 36.3 - 37.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-16_Core002.jpg	4-11-06	SNL-16 drillpad; T22S, R30E, sec 33	Close-up photo of Gatuna/Forty-niner Mbr core, 36.9 - 38.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-16_Core003.jpg	4-11-06	SNL-16 drillpad; T22S, R30E, sec 33	Close-up photo of Forty-niner Mbr core, 37.9 - 39.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-16_Core004.jpg	4-11-06	SNL-16 drillpad; T22S, R30E, sec 33	Close-up photo of Forty-niner Mbr core, 38.9 - 40.2 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-16_Core005.jpg	4-11-06	SNL-16 drillpad; T22S, R30E, sec 33	Close-up photo of Forty-niner Mbr core, 39.9 - 41.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-16_Core006.jpg	4-11-06	SNL-16 drillpad; T22S, R30E, sec 33	Close-up photo of Forty-niner Mbr core, 40.9 - 42.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-16_Core007.jpg	4-11-06	SNL-16 drillpad; T22S, R30E, sec 33	Close-up photo of Forty-niner Mbr core, 41.9 - 43.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-16_Core008.jpg	4-11-06	SNL-16 drillpad; T22S, R30E, sec 33	Close-up photo of Forty-niner Mbr core, 42.9 - 44.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-16_Core009.jpg	4-11-06	SNL-16 drillpad; T22S, R30E, sec 33	Close-up photo of Forty-niner and Magenta Dolomite Mbr core, 43.9 - 45.2 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-16_Core010.jpg	4-11-06	SNL-16 drillpad; T22S, R30E, sec 33	Close-up photo of Magenta Dolomite Mbr core, 44.9 - 46.2 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-16_Core011.jpg	4-11-06	SNL-16 drillpad; T22S, R30E, sec 33	Close-up photo of Magenta Doloimite Mbr core, 45.9.9 - 46.5 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-16_Core012.jpg	4-11-06	SNL-16 drillpad; T22S, R30E, sec 33	Close-up photo of Magenta Dolomite Mbr core, 46.5 - 47.2 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-16_Core013.jpg	4-11-06	SNL-16 drillpad; T22S, R30E, sec 33	Close-up photo of Magenta Dolomite Mbr core, 46.9 - 48.2 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-16_Core014.jpg	4-11-06	SNL-16 drillpad; T22S, R30E, sec 33	Close-up photo of Magenta Dolomite Mbr core, 47.9 - 49.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-16_Core015.jpg	4-11-06	SNL-16 drillpad; T22S, R30E, sec 33	Close-up photo of Magenta Dolomite Mbr core, 48.9 - 50.2 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-16_Core016.jpg	4-11-06	SNL-16 drillpad; T22S, R30E, sec 33	Close-up photo of Magenta Dolomite Mbr core, 49.9 - 51.2 ft bgl, with markings, scale	DW Powers Consultant to WTS

File	DATE	LOCATION	DESCRIPTION OF SUBJECT (includes individual/group names, direction, etc. as appropriate)	PHOTOGRAPHER (initials and dept.)
SNL-16_Core017.jpg	4-11-06	SNL-16 drillpad; T22S, R30E, sec 33	Close-up photo of Magenta Dolomite Mbr core, 50.9 - 52.2 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-16_Core018.jpg	4-11-06	SNL-16 drillpad; T22S, R30E, sec 33	Close-up photo of Magenta Dolomite Mbr core, 51.9 - 53.2 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-16_Core019.jpg	4-11-06	SNL-16 drillpad; T22S, R30E, sec 33	Close-up photo of Magenta Dolomite Mbr core, 52.9 - 54.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-16_Core020.jpg	4-11-06	SNL-16 drillpad; T22S, R30E, sec 33	Close-up photo of Magenta Dolomite Mbr core, 53.9 - 55.2 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-16_Core021.jpg	4-11-06	SNL-16 drillpad; T22S, R30E, sec 33	Close-up photo of Magenta Dolomite Mbr core, 54.9 - 56.2 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-16_Core022.jpg	4-11-06	SNL-16 drillpad; T22S, R30E, sec 33	Close-up photo of Magenta Dolomite Mbr core, 55.9 - 57.2 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-16_Core023.jpg	4-11-06	SNL-16 drillpad; T22S, R30E, sec 33	Close-up photo of Magenta Dolomite Mbr core, 56.8 - 58.2 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-16_Core024.jpg	4-11-06	SNL-16 drillpad; T22S, R30E, sec 33	Close-up photo of Magenta Dolomite Mbr core, 57.9 - 59.2 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-16_Core025.jpg	4-11-06	SNL-16 drillpad; T22S, R30E, sec 33	Close-up photo of Magenta Dolomite Mbr core, 58.8 - 59.3 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-16_Core026.jpg	4-11-06	SNL-16 drillpad; T22S, R30E, sec 33	Close-up photo of Magenta Dolomite Mbr core, 59.3 - 60.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-16_Core027.jpg	4-11-06	SNL-16 drillpad; T22S, R30E, sec 33	Close-up photo of Magenta Dolomite Mbr core, 59.9 - 61.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-16_Core028.jpg	4-11-06	SNL-16 drillpad; T22S, R30E, sec 33	Close-up photo of Magenta Dolomite Mbr core, 60.8 - 62.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-16_Core029.jpg	4-11-06	SNL-16 drillpad; T22S, R30E, sec 33	Close-up photo of Magenta Dolomite Mbr core, 61.8 - 63.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-16_Core030.jpg	4-11-06	SNL-16 drillpad; T22S, R30E, sec 33	Close-up photo of Magenta Dolomite Mbr core, 62.8 - 64.2 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-16_Core031.jpg	4-11-06	SNL-16 drillpad; T22S, R30E, sec 33	Close-up photo of Magenta Dolomite Mbr core, 63.9 - 65.2 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-16_Core032.jpg	4-11-06	SNL-16 drillpad; T22S, R30E, sec 33	Close-up photo of Magenta Dolomite Mbr core, 64.7 - 66.2 ft bgl, with markings, scale	DW Powers Consultant to WTS

File	DATE	LOCATION	DESCRIPTION OF SUBJECT (includes individual/group names, direction, etc. as appropriate)	PHOTOGRAPHER (initials and dept.)
SNL-16_Core033.jpg	4-11-06	SNL-16 drillpad; T22S, R30E, sec 33	Close-up photo of Magenta Dolomite core, 65.8 - 67.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-16_Core034.jpg	4-11-06	SNL-16 drillpad; T22S, R30E, sec 33	Close-up photo of Magenta Dolomite Mbr core, 66.8 - 68.2 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-16_Core035.jpg	4-11-06	SNL-16 drillpad; T22S, R30E, sec 33	Close-up photo of Magenta Dolomite Mbr core, 67.8 - 69.2 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-16_Core036.jpg	4-11-06	SNL-16 drillpad; T22S, R30E, sec 33	Close-up photo of Magenta Dolomite Mbr core, 68.8 - 70.2 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-16_Core037.jpg	4-11-06	SNL-16 drillpad; T22S, R30E, sec 33	Close-up photo of Magenta Dolomite Mbr core, 69.8 - 71.2 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-16_Core038.jpg	4-11-06	SNL-16 drillpad; T22S, R30E, sec 33	Close-up photo of Magenta Dolomite Mbr core, 71.8 - 72.2 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-16_Core039.jpg	4-11-06	SNL-16 drillpad; T22S, R30E, sec 33	Close-up photo of Magenta Dolomite Mbr core, 71.8 - 73.0 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-16_Core040.jpg	4-13-06	SNL-16 drillpad; T22S, R30E, sec 33	Close-up photo of Tamarisk Mbr core, 176.5 - 177.2 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-16_Core041.jpg	4-13-06	SNL-16 drillpad; T22S, R30E, sec 33	Close-up photo of Tamarisk Mbr core, 176.9 - 178.2 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-16_Core042.jpg	4-13-06	SNL-16 drillpad; T22S, R30E, sec 33	Close-up photo of Tamarisk Mbr core, 177.9 - 179.2 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-16_Core043.jpg	4-13-06	SNL-16 drillpad; T22S, R30E, sec 33	Close-up photo of Tamarisk Mbr core, 178.9 - 180.2 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-16_Core044.jpg	4-13-06	SNL-16 drillpad; T22S, R30E, sec 33	Close-up photo of Tamarisk Mbr core, 179.9 - 181.2 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-16_Core045.jpg	4-13-06	SNL-16 drillpad; T22S, R30E, sec 33	Close-up photo of Tamarisk Mbr core, 180.8 - 182.2 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-16_Core046.jpg	4-13-06	SNL-16 drillpad; T22S, R30E, sec 33	Close-up photo of Tamarisk Mbr core, 181.8 - 183.2 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-16_Core047.jpg	4-13-06	SNL-16 drillpad; T22S, R30E, sec 33	Close-up photo of Tamarisk Mbr core, 182.8 - 184.2 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-16_Core048.jpg	4-13-06	SNL-16 drillpad; T22S, R30E, sec 33	Close-up photo of Tamarisk Mbr core, 183.8 - 185.0 ft bgl, with markings, scale	DW Powers Consultant to WTS

File	DATE	LOCATION	DESCRIPTION OF SUBJECT (includes individual/group names, direction, etc. as appropriate)	PHOTOGRAPHER (initials and dept.)
SNL-16_Core049.jpg	4-13-06	SNL-16 drillpad; T22S, R30E, sec 33	Close-up photo of Tamarisk Mbr core, 185.0 - 186.2 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-16_Core050.jpg	4-13-06	SNL-16 drillpad; T22S, R30E, sec 33	Close-up photo of Tamarisk Mbr core, 185.8 - 187.2 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-16_Core051.jpg	4-13-06	SNL-16 drillpad; T22S, R30E, sec 33	Close-up photo of Tamarisk Mbr core, 186.8 - 188.2 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-16_Core052.jpg	4-13-06	SNL-16 drillpad; T22S, R30E, sec 33	Close-up photo of Tamarisk Mbr core, 187.8 - 189.2 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-16_Core053.jpg	4-13-06	SNL-16 drillpad; T22S, R30E, sec 33	Close-up photo of Tamarisk Mbr core, 188.8 - 190.2 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-16_Core054.jpg	4-13-06	SNL-16 drillpad; T22S, R30E, sec 33	Close-up photo of Tamarisk and Culebra Dolomite Mbr core, 189.8 - 191.2 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-16_Core055.jpg	4-13-06	SNL-16 drillpad; T22S, R30E, sec 33	Close-up photo of Culebra Dolomite Mbr core, 190.8 - 192.2 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-16_Core056.jpg	4-13-06	SNL-16 drillpad; T22S, R30E, sec 33	Close-up photo of Culebra Dolomite Mbr core, 191.8 - 193.2 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-16_Core057.jpg	4-13-06	SNL-16 drillpad; T22S, R30E, sec 33	Close-up photo of Culebra Dolomite Mbr core, 192.8 - 194.2 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-16_Core058.jpg	4-13-06	SNL-16 drillpad; T22S, R30E, sec 33	Close-up photo of Culebra Dolomite Mbr core, 193.8 - 195.2 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-16_Core059.jpg	4-13-06	SNL-16 drillpad; T22S, R30E, sec 33	Close-up photo of Culebra Dolomite Mbr core, 194.8 - 196.0 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-16_Core060.jpg	4-13-06	SNL-16 drillpad; T22S, R30E, sec 33	Close-up photo of Culebra Dolomite Mbr core, 197.3 - 198.2 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-16_Core061.jpg	4-13-06	SNL-16 drillpad; T22S, R30E, sec 33	Close-up photo of Culebra Dolomite Mbr core, 197.8 - 199.2 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-16_Core062.jpg	4-13-06	SNL-16 drillpad; T22S, R30E, sec 33	Close-up photo of Culebra Dolomite Mbr core, 198.7 - 200.2 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-16_Core063.jpg	4-13-06	SNL-16 drillpad; T22S, R30E, sec 33	Close-up photo of Culebra Dolomite Mbr core, 199.7 - 201.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-16_Core064.jpg	4-13-06	SNL-16 drillpad; T22S, R30E, sec 33	Close-up photo of Culebra Dolomite Mbr core, 200.8 - 202.0 ft bgl, with markings, scale	DW Powers Consultant to WTS

File	DATE	LOCATION	DESCRIPTION OF SUBJECT (includes individual/group names, direction, etc. as appropriate)	PHOTOGRAPHER (initials and dept.)
SNL-16_Core065.jpg	4-13-06	SNL-16 drillpad; T22S, R30E, sec 33	Close-up photo of Culebra Dolomite Mbr core, 201.8 - 203.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-16_Core066.jpg	4-13-06	SNL-16 drillpad; T22S, R30E, sec 33	Close-up photo of Culebra Dolomite Mbr core, 202.8 - 204.0 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-16_Core067.jpg	4-13-06	SNL-16 drillpad; T22S, R30E, sec 33	Close-up photo of Culebra Dolomite Mbr core, 203.8 - 204.2 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-16_Core068.jpg	4-13-06	SNL-16 drillpad; T22S, R30E, sec 33	Close-up photo of Culebra Dolomite Mbr core, 203.8 - 205.1 ft bgl, with scale	DW Powers Consultant to WTS
SNL-16_Core069.jpg	4-13-06	SNL-16 drillpad; T22S, R30E, sec 33	Close-up photo of Culebra Dolomite Mbr core, 204.8 - 206.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-16_Core070.jpg	4-13-06	SNL-16 drillpad; T22S, R30E, sec 33	Close-up photo of Culebra Dolomite Mbr core, 205.7 - 206.4 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-16_Core071.jpg	4-14-06	SNL-16 drillpad; T22S, R30E, sec 33	Close-up photo of Culebra Dolomite Mbr core, 213.8 - 215.2 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-16_Core072.jpg	4-14-06	SNL-16 drillpad; T22S, R30E, sec 33	Close-up photo of Culebra Dolomite/ Los Medaños Mbrs core, 214.8 - 216.2 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-16_Core073.jpg	4-14-06	SNL-16 drillpad; T22S, R30E, sec 33	Close-up photo of Los Medaños Mbr core, 215.8 - 217.2 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-16_Core074.jpg	4-14-06	SNL-16 drillpad; T22S, R30E, sec 33	Close-up photo of Los Medaños Mbr core, 216.8 - 218.3 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-16_Core075.jpg	4-14-06	SNL-16 drillpad; T22S, R30E, sec 33	Close-up photo of Los Medaños Mbr core, 217.7 - 219.3 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-16_Core076.jpg	4-14-06	SNL-16 drillpad; T22S, R30E, sec 33	Close-up photo of Los Medaños Mbr core, 218.7 - 219.3 with markings, scale	DW Powers Consultant to WTS
SNL-16_Core077.jpg	4-17-06	SNL-16 drillpad; T22S, R30E, sec 33	Close-up photo of Los Medaños Mbr core, 224.3 - 225.2 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-16_Core078.jpg	4-17-06	SNL-16 drillpad; T22S, R30E, sec 33	Close-up photo of Los Medaños Mbr core, 224.9 - 226.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-16_Core079.jpg	4-17-06	SNL-16 drillpad; T22S, R30E, sec 33	Close-up photo of Los Medaños Mbr core, 225.9 - 227.3 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-16_Core080.jpg	4-17-06	SNL-16 drillpad; T22S, R30E, sec 33	Close-up photo of Los Medaños Mbr core, 226.8 - 228.2 ft bgl, with markings, scale	DW Powers Consultant to WTS

File	DATE	LOCATION	DESCRIPTION OF SUBJECT (includes individual/group names, direction, etc. as appropriate)	PHOTOGRAPHER (initials and dept.)
SNL-16_Core081.jpg	4-17-06	SNL-16 drillpad; T22S, R30E, sec 33	Close-up photo of Los Medaños Mbr core, 227.8 - 229.3 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-16_Core082.jpg	4-17-06	SNL-16 drillpad; T22S, R30E, sec 33	Close-up photo of Los Medaños Mbr core, 228.8 - 230.2 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-16_Core083.jpg	4-17-06	SNL-16 drillpad; T22S, R30E, sec 33	Close-up photo of Los Medaños Mbr core, 229.8 - 231.2 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-16_Core084.jpg	4-17-06	SNL-16 drillpad; T22S, R30E, sec 33	Close-up photo of Los Medaños Mbr core, 230.8 - 232.2 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-16_Core085.jpg	4-17-06	SNL-16 drillpad; T22S, R30E, sec 33	Close-up photo of Los Medaños Mbr core, 231.8 - 233.2 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-16_Core086.jpg	4-17-06	SNL-16 drillpad; T22S, R30E, sec 33	Close-up photo of Los Medaños Mbr core, 232.8 - 234.2 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-16_Core087.jpg	4-17-06	SNL-16 drillpad; T22S, R30E, sec 33	Close-up photo of Los Medaños Mbr core, 233.8 - 235.2 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-16_Core088.jpg	4-17-06	SNL-16 drillpad; T22S, R30E, sec 33	Close-up photo of Los Medaños Mbr core, 234.8 - 236.3 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-16_Core089.jpg	4-17-06	SNL-16 drillpad; T22S, R30E, sec 33	Close-up photo of Los Medaños Mbr core, 235.8 - 237.2 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-16_Core090.jpg	4-17-06	SNL-16 drillpad; T22S, R30E, sec 33	Close-up photo of Los Medaños Mbr core, 236.8 - 238.2 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-16_Core091.jpg	4-17-06	SNL-16 drillpad; T22S, R30E, sec 33	Close-up photo of Los Medaños Mbr core, 237.8 - 239.0 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-16_Core092.jpg	4-17-06	SNL-16 drillpad; T22S, R30E, sec 33	Close-up photo of Los Medaños Mbr core, 239.0 - 240.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-16_Core093.jpg	4-17-06	SNL-16 drillpad; T22S, R30E, sec 33	Close-up photo of Los Medaños Mbr core, 239.9 - 241.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-16_Core094.jpg	4-17-06	SNL-16 drillpad; T22S, R30E, sec 33	Close-up photo of Los Medaños Mbr core, 240.9 - 242.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-16_Core095.jpg	4-17-06	SNL-16 drillpad; T22S, R30E, sec 33	Close-up photo of Los Medaños Mbr core, 241.8 - 243.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-16_Core096.jpg	4-17-06	SNL-16 drillpad; T22S, R30E, sec 33	Close-up photo of Los Medaños Mbr core, 242.8 - 244.1 ft bgl, with markings, scale	DW Powers Consultant to WTS

File	DATE	LOCATION	DESCRIPTION OF SUBJECT (includes individual/group names, direction, etc. as appropriate)	PHOTOGRAPHER (initials and dept.)
SNL-16_Core097.jpg	4-17-06	SNL-16 drillpad; T22S, R30E, sec 33	Close-up photo of Los Medaños Mbr core, 243.7 - 245.0 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-16_Core098.jpg	4-17-06	SNL-16 drillpad; T22S, R30E, sec 33	Close-up photo of Los Medaños Mbr core, 244.8 - 246.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-16_Core099.jpg	4-17-06	SNL-16 drillpad; T22S, R30E, sec 33	Close-up photo of Los Medaños Mbr core, 245.8 - 247.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-16_Core100.jpg	4-17-06	SNL-16 drillpad; T22S, R30E, sec 33	Close-up photo of Los Medaños Mbr core, 246.8 - 248.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-16_Core101.jpg	4-17-06	SNL-16 drillpad; T22S, R30E, sec 33	Close-up photo of Los Medaños Mbr core, 247.7 - 249.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-16_Core102.jpg	4-17-06	SNL-16 drillpad; T22S, R30E, sec 33	Close-up photo of Los Medaños Mbr core, 248.7 - 250.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-16_Core103.jpg	4-17-06	SNL-16 drillpad; T22S, R30E, sec 33	Close-up photo of Los Medaños Mbr core, 249.7 - 251.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-16_Core104.jpg	4-17-06	SNL-16 drillpad; T22S, R30E, sec 33	Close-up photo of Los Medaños Mbr core, 250.7 - 252.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-16_Core105.jpg	4-17-06	SNL-16 drillpad; T22S, R30E, sec 33	Close-up photo of Los Medaños Mbr core, 251.8 - 253.0 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-16_Core106.jpg	4-17-06	SNL-16 drillpad; T22S, R30E, sec 33	Close-up photo of Los Medaños Mbr core, 278.3 - 279.2 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-16_Core107.jpg	4-17-06	SNL-16 drillpad; T22S, R30E, sec 33	Close-up photo of Los Medaños Mbr core, 278.9 - 280.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-16_Core108.jpg	4-17-06	SNL-16 drillpad; T22S, R30E, sec 33	Close-up photo of Los Medaños Mbr core, 279.8 - 281.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-16_Core109.jpg	4-17-06	SNL-16 drillpad; T22S, R30E, sec 33	Close-up photo of Los Medaños Mbr core, 280.8 - 282.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-16_Core110.jpg	4-17-06	SNL-16 drillpad; T22S, R30E, sec 33	Close-up photo of Los Medaños Mbr core, 281.8 - 283.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-16_Core111.jpg	4-17-06	SNL-16 drillpad; T22S, R30E, sec 33	Close-up photo of Los Medaños Mbr core, 282.7 - 284.3 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-16_Core112.jpg	4-17-06	SNL-16 drillpad; T22S, R30E, sec 33	Close-up photo of Los Medaños Mbr recovered from core catcher @ 299.3 ft bgl, without markings or scale	DW Powers Consultant to WTS

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

Appendix G
Geophysical and Video Logs

Geophysical logging of SNL-16 was conducted by Jet West Geophysical Services, LLC, 2550 La Plata Highway, Farmington, NM, 87499-3522, on April 18, 2006. The operator was Al Henderson. Copies of the logs are maintained by Washington Regulatory and Environmental Services, Environmental Monitoring and Hydrology Section, for the WIPP project. A CD-ROM is being retained that includes:

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

The following geophysical logs were obtained:

- Caliper
- Natural gamma
- Density-porosity
- Neutron
- Resistivity
- Spontaneous potential

SNL-16 had been cored and drilled to about 299 ft at the time of logging. Fill in the hole prevented logging below 287 ft. A conductor casing had been placed to a depth of 35 ft bgl. The fluid level in the drillhole, from drilling and inflow, rose to approximately 120 ft below the surface at the time of logging. SNL-16 was drilled with air and foam.

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

The reference point (0 ft depth) for geophysical logging was the top of the surface conductor casing. This point was not assigned an elevation on the logs. A benchmark placed near the drillhole after completion has an elevation of 3130.21 ft amsl (see Fig. 1-5 and Table 1-1 in the main text). The rounded elevation of 3130 ft amsl for the reference point is appropriate for the measurements and elevations of units for later studies.

On April 12, 2006, a video camera was used to obtain images of the borehole. The video camera is the property of Sandia National Laboratories, Carlsbad, NM.

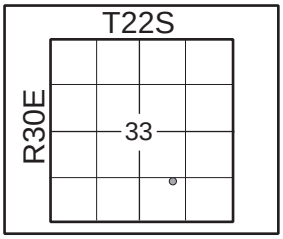
The camera run was recorded on a VHS tape that is retained by SNL Records with a record number ERMS #543800.

Anne Schaub (SNL, left) preparing to record downhole video camera run in SNL-16 on April 12, 2006.

Ed Schaub (SNL, left below) and Mike Hillesheim (SNL, right below) clean video camera equipment following downhole run in SNL-16 on April 12, 2006.

Figure 2-1
Well Record SNL-16 (C-3220)

Company: Washington TRU Solutions LLC
Well: SNL-16 (C-3220)
Section: 33 Twp: T22S Rge: R30E
Location: 1,220 ft from south line (fsl)
1,565 ft from east line (fel)



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

Elevation
KB:
DF:
GL: 3,130 ft amsl
(benchmark: 3,130.21)

Drilling contractor: West Texas Well Water Service
Coring contractor: Diamond Oil Well Drilling Co.
Geophysical logs: Al Henderson
Jet West Geophysical Services, LLC (NM)
Geologist: Dennis W. Powers
Spud date: April 10, 2006
Completion date: April 19, 2006
Total depth (TD): 299.3 ft bgl (driller log)

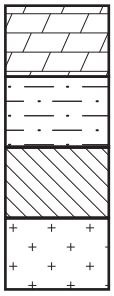
Casing Record
Conductor: 35 ft
12.75 inch o.d. steel
Casing: 5.45 inch o.d.
fiberglass reinforced
plastic to 226.5 ft bgl
Screened interval:
216.00-189.85 ft bgl

Geophysical Logs Date: April 18, 2006

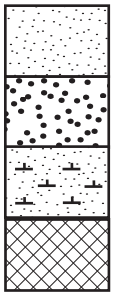
Micro/Laterolog/SP:	125-282 ft
Gamma	0-285 ft
Caliper:	0-285 ft
Density/Neutron:	0-285 ft

Type fluid in hole: water
from drillhole to 120 ft
Res mud: n/a
Res mud filtrate: n/a
Max. Rec. Temp.:
not recorded

General Lithologic Symbols Used



Dolomite
Mudstone/siltstone
Anhydrite
Halite



Fine sandstone & siltstone
Coarse sandstone
Sandstone w/caliche
Polyhalite

Figure 2-1 Log Title & Header page.ai

SNL-16 Well Log Headers

Radioactive Logs
Neutron 0 0 API counts
Density 2.0 3.0 g/cc
Density Porosity 60 0 per cent
API counts 1000 5000

Resistivity/Conductivity
Single Point Res 1 1000 Ohm
64" Normal Res 1 1000 Ohm
16" Normal Res 1 1000 Ohm

feet amsl
Elevation
meters amsl
GL = 3130 ft (954 m) amsl
Lithology
cored
feet bgs
Depth
meters bgs

Caliper 6.0 16.0 inches
Gamma 0 200 API units
SP -100 100 mV

Stratigraphy
Member
Formation
Group
System

Stratigraphy
System
Group
Formation
Member

Caliper
6.0 inches 16.0
Gamma
0 API units 200
SP
-100 mV 100

Depth
meters bgs
feet bgs

Lithology
cored

Elevation
meters amsl
feet amsl

GL = 3130 ft (954 m) amsl

Resistivity/Conductivity
Single Point Res
1 Ohm 1000
64" Normal Res
1 Ohm 1000
16" Normal Res
1 Ohm 1000

Radioactive Logs
Neutron 0 API counts 5000
0 API counts 1000
Density
2.0 g/cc 3.0
Density Porosity
60 per cent 0

Permian (Ochoan)

Rustler

Sand
Mescalero
Gatuna
Forty-niner
Magenta
Tamarisk
Culebra
Los Medaños

0 25 50 75 100 125 150 175 200 225 250 275 300
0 10 20 30 40 50 60 70 80 90
950 940 930 920 910 900 890 880 870
3100 3050 3000 2950 2900 2850

35 ft - Base of conductor casing

Neutron log dash pattern; scale 0-5000
0 2500 5000

Top of water in drillhole at time of logging
1.0 2.0 3.0

Neutron log changed to dot pattern; scale 0-1000
0 250 500 750 1000
1.0 2.0 3.0

Bottom of hole filled from 299.3 to 232 ft before reaming to 228 ft.

p.92-93