DOE/WIPP-05-3325

Basic Data Report
For Drillhole SNL-15 (C-3152)
(Waste Isolation Pilot Plant)

September 2008

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Basic Data Report
For Drillhole SNL-15 (C-3152)
(Waste Isolation Pilot Plant)

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September 2008

West Texas Water Well Service, Rig #15 at SNL-15, viewed toward the west. The 7.875-inch rotary bit has been laid down, and the crew is tripping in to begin coring using compressed air. Photo taken June 5, 2005, by Dennis W. Powers.

EXECUTIVE SUMMARY

SNL-15 (permitted by the New Mexico State Engineer as C-3152) was drilled and completed in early June 2005 to provide geological data and hydrological testing of the Culebra Dolomite Member of the Permian Rustler Formation in an area east of the Waste Isolation Pilot Plant (WIPP) site where data are sparse and where Culebra transmissivity is expected to be very low. SNL-15 is located near the southeast corner of section 26, T22S, R31E, in eastern Eddy County, New Mexico. SNL-15 was drilled to a total depth of 950 ft below ground level (bgl), based on driller's measurements. Below the caliche pad, SNL-15 encountered the Mescalero caliche, Gatuña, Santa Rosa, Dewey Lake, and Rustler Formations. The Rustler was cored from the lower Tamarisk Member through the Culebra Dolomite and into the upper Los Medaños Member. Geophysical logs were acquired from the open hole to a depth of ~938 ft. No water was observed flowing into the open drillhole during drilling.

The upper part of the Los Medaños has normal lithology, thickness, and stratigraphic sequence for areas east of WIPP. The upper clastic-halite unit of the Los Medaños (M-2/H-2) at SNL-15 was well preserved in cores, and it was dominated by halite, consistent with expectations based on previous drilling at this location. The halite is medium-to-coarse crystalline, generally white to brown, and it is bedded and interbedded with thin mudstone layers. The halite displays both displacive and incorporative growth. The contact with the overlying Culebra was recovered as a single core, and the uppermost core from M-2 is well-laminated gray silty claystone, does not indicate significant deformation, and grades sharply into the overlying dolomite.

Core recovery from the Culebra was complete, revealing a unit with no observable open porosity. There are some narrow fractures within the core, and they are filled or lined with halite that is generally fibrous. Some sulfate vug fillings also exhibits coarse, clear halite cements. Smaller vugs are present in the lower third of the Culebra, below ~924 ft (as marked on the core), but they also are filled with dolomite(?) silt. Some subhorizontal bedding occurs throughout the core, and there are concentrated laminae at ~923 ft and 910 ft. Small sulfate nodules are more abundant in the upper 1 ft of the Culebra than in most such cores, and the more organic-rich zone that commonly marks the top of dolomite is just below the nodular zone. The Culebra is 30.5 ft thick in core and 30 ft thick as interpreted by geophysical logs. This is thicker than normal for the WIPP site, but it is consistent with modest thickening toward the east and southeast previously interpreted. Given the presence of halite and filled fractures and porosity, the Culebra will have low transmissivity compared to most wells tested at WIPP.

The Tamarisk has a normal stratigraphic sequence for the area east of WIPP and greater thickness than at the WIPP site because of halite beds. Only the lower few feet of the Tamarisk were recoverd as core. Geophysical logs and cuttings are the basis for interpreting the rest of the unit. The basal sulfate unit (A-2) includes horizontal beds and laminae near the base. The geophysical log shows a thin argillaceous zone in the upper part of A-2 that is persistent across the WIPP area. At SNL-15, halite (H-3) dominates over mudstone (M-3). Halite overlies A-2, followed by mixed halite and mudstone that is ~16 ft thick. Above the mixed zone, a sulfate and halite bed ~12 ft thick includes ~2-4 ft of polyhalite at the top. This sulfate bed persists east and southeast of the WIPP site as a stratigraphic unit. Nearly 50 ft of halite, with another thin sulfate bed, cap the polyhalite and are the final deposit of the M-3/H-3 complex. The upper Tamarisk sulfate (A-3) is nearly 55 ft thick, consistent with other encounters in the area.

The Magenta Dolomite is ~24 ft thick, based on geophysical logs. The Magenta was not cored, and cuttings revealed only general composition of dolomite and some sulfate. Resistivity logs

showed the Magenta to be more conductive than underlying and overlying anhydrite beds. There are some modest differences in resistivity in the upper part of the Magenta, but no indications of groundwater inflow.

The Forty-niner is represented by a sequence of sulfate–halite and mudstone–sulfate sequence. The basal anhydrite (A-4) is ~16 ft thick and shows little evidence of gypsification. M-4/H-4 is dominated by halite, with a more argillaceous zone, ~10 ft thick in the middle. At 660 ft, a thin, higher density bed is likely to be sulfatic and may even be somewhat polyhalitic, given a modestly elevated natural gamma. There are upper and lower halite zones in M-4/H-4 that show little natural gamma and should be nearly pure halite. The upper anhydrite (A-5) of the Forty-niner is 28 ft thick, and the contact with the overlying Dewey Lake appears sharp on the logs.

The Dewey Lake is thicker at SNL-15 than in drillholes farther west where the upper part of the formation has been eroded. Cuttings showed more gypsum and probable sulfate cement below 250 ft, and induction resistivity increased and remained higher below that point. This is among the higher stratigraphic positions where this cement has been encountered in WIPP drillholes.

The remaining Santa Rosa Formation at SNL-15 is represented by interbedded reddish-brown siltstones and sandstones.

The Gatuña at SNL-15 is mainly calcareous sandstone, with carbonate infiltrated at the top. Manganese oxide stains found here in the Gatuña are also common elsewhere in the formation.

The Mescalero caliche is moderately indurated at SNL-15, but cuttings were insufficient to determine the stage of development.

SNL-15 was drilled (and reamed through cored intervals) with an original diameter of 7.875 inches to the depth for completion. Fiberglass reinforced plastic (FRP) tubing (2.48 inches inside diameter) was placed in the hole, with a screen interval across the Culebra Dolomite from 928.5–902.0 ft below the top of the connector on the conductor casing. Because of the low transmissivity of the Culebra in this area, no pumping test is anticipated that would require larger casing. Approximately 2.5 ft of FRP casing was left above the connector. HolePlug® (bentonite) was placed in the bottom of the hole to 935 ft, and the annulus was filled with 4/10 gravel to 896 ft, above the Culebra. HolePlug® was placed from 896–891 ft to separate the Culebra from the Tamarisk mudstone. The annulus above the bentonite was cemented to the surface.

SNL-15 was completed June 7, 2005. SNL (Sandia National Laboratories) installed a miniTroll on June 23, 2005, to monitor pressure changes in response to testing at other wells and recovery after drilling. The first water level recorded by Washington Regulatory and Environmental Services (WRES) was measured April 11, 2006; water was 692.67 ft below the top of the casing.

Table of Contents

List of Figures and Tables

In keeping with practice at the WIPP site, the basic data for SNL-15 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)

Drilling Crew for West Texas Water Well Service on SNL-15: Luis Armendariz (l: driller), Israel Galván (c), and Reuben Bugarin (r). Photo by Dennis W. Powers, June 5, 2005.

1.0 INTRODUCTION

SNL-15 was drilled near the southeast corner of section 26, T22S, R31E, in eastern Eddy County, New Mexico (Fig. 1-1). It is located 102 ft from the south line (fsl) and 807 ft from the east line (fel) of the section (Fig. 1-2). This location places the drillhole east of the WIPP site and on the drillpad used for P-18 (Jones, 1978), which has now been plugged and abandoned. SNL-15 was begun on June 1, 2005, and was completed June 7. SNL-15 will be used to monitor groundwater levels of the Culebra Dolomite Member of the Permian Rustler Formation for the WIPP in an area of very low transmissivity.

SNL-15 was permitted by the New Mexico State Engineer as C-3152. Official correspondence regarding permitting and regulatory information must reference this permit number.

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

1.1 Purpose of WIPP

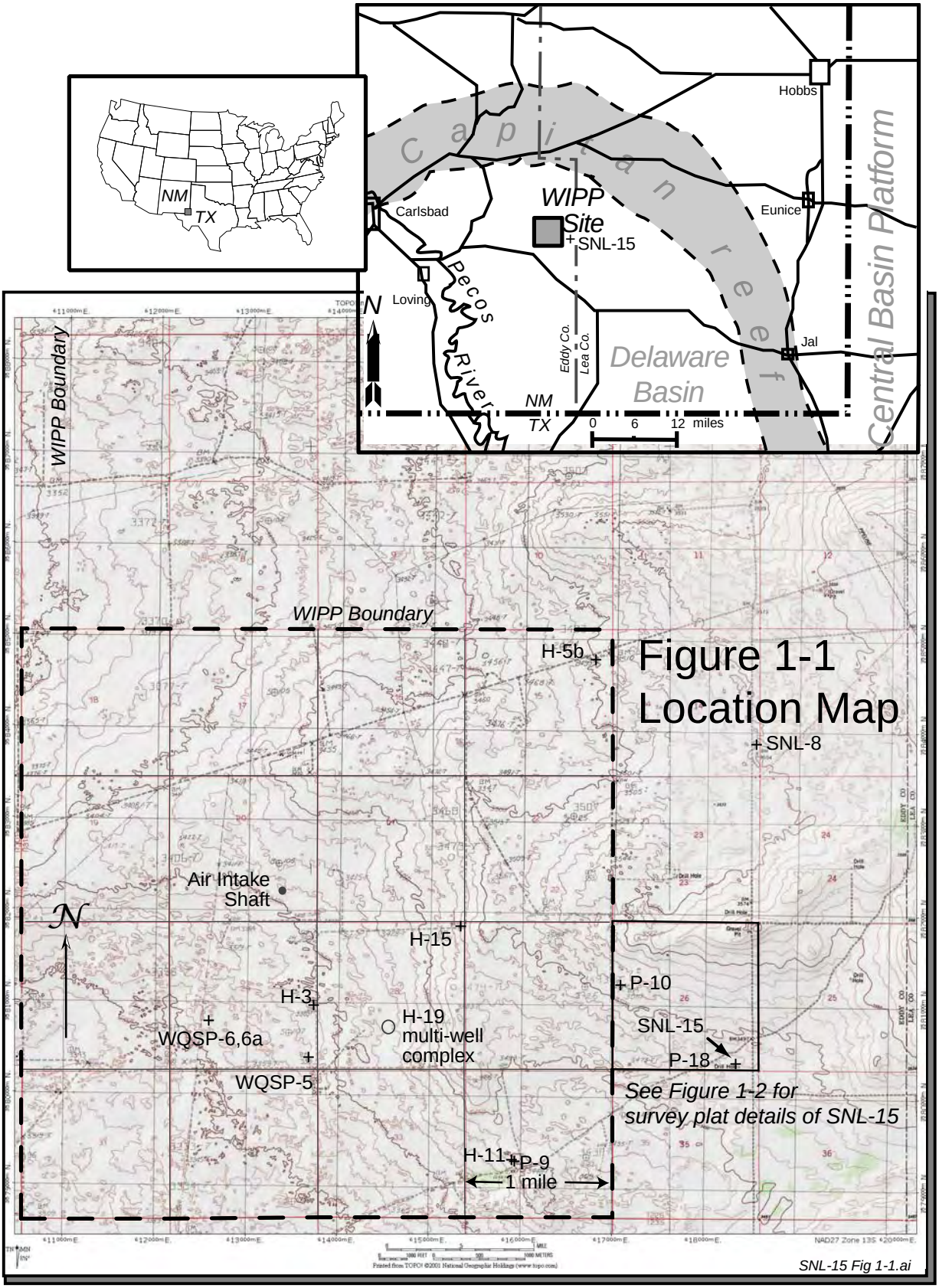
WIPP is a U.S. Department of Energy (DOE) facility disposing of transuranic and mixed waste, byproducts of U.S. defense programs, as certified by the U.S. Environmental Protection Agency (EPA) and under a permit issued by the New Mexico Environment Department. WIPP is located about 25 miles east of Carlsbad,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

1.2 Purpose of SNL-15

SNL-15 was designed and located to provide information for the integrated hydrology program for the WIPP (Sandia National Laboratories [SNL], 2003). Among the objectives of the integrated hydrology program, SNL-15 will help "… resolve questions related to observed water-level changes around the WIPP site, provide data needed for comprehensive modeling of WIPP groundwater hydrology, [and] construct a groundwater monitoring network that can be maintained throughout the operational period of WIPP …" (p. 1).

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

SNL-15 was located east of WIPP where data are sparse and where Culebra transmissivity is believed to be very low, although hydraulic data from P-18 are poorly constrained (Beauheim, 1987). In addition, geologic data obtained from the drillhole would help confirm the effects of Rustler halite on Culebra hydraulic properties. No well designated SNL-15 was included in the program plan (SNL, 2003), but it is located at the site designated WTS-3. From the program plan (SNL, 2003) and other documents (Appendix A),


NM
TX
Hobbs
Carlsbad
WIPP Site
SNL-15
Eunice
Loving
Pecos River
Jal
Eddy Co.
Lea Co.
Delaware Basin
Capitan reef
Central Basin Platform
0 6 12 miles
N
WIPP Boundary
WIPP Boundary
H-5b
SNL-8
Air Intake Shaft
H-15
H-3
H-19 multi-well complex
WQSP-6,6a
WQSP-5
P-10
SNL-15
P-18
See Figure 1-2 for survey plat details of SNL-15
H-11
P-9
1 mile
Figure 1-1
Location Map
SNL-15 Fig 1-1.ai

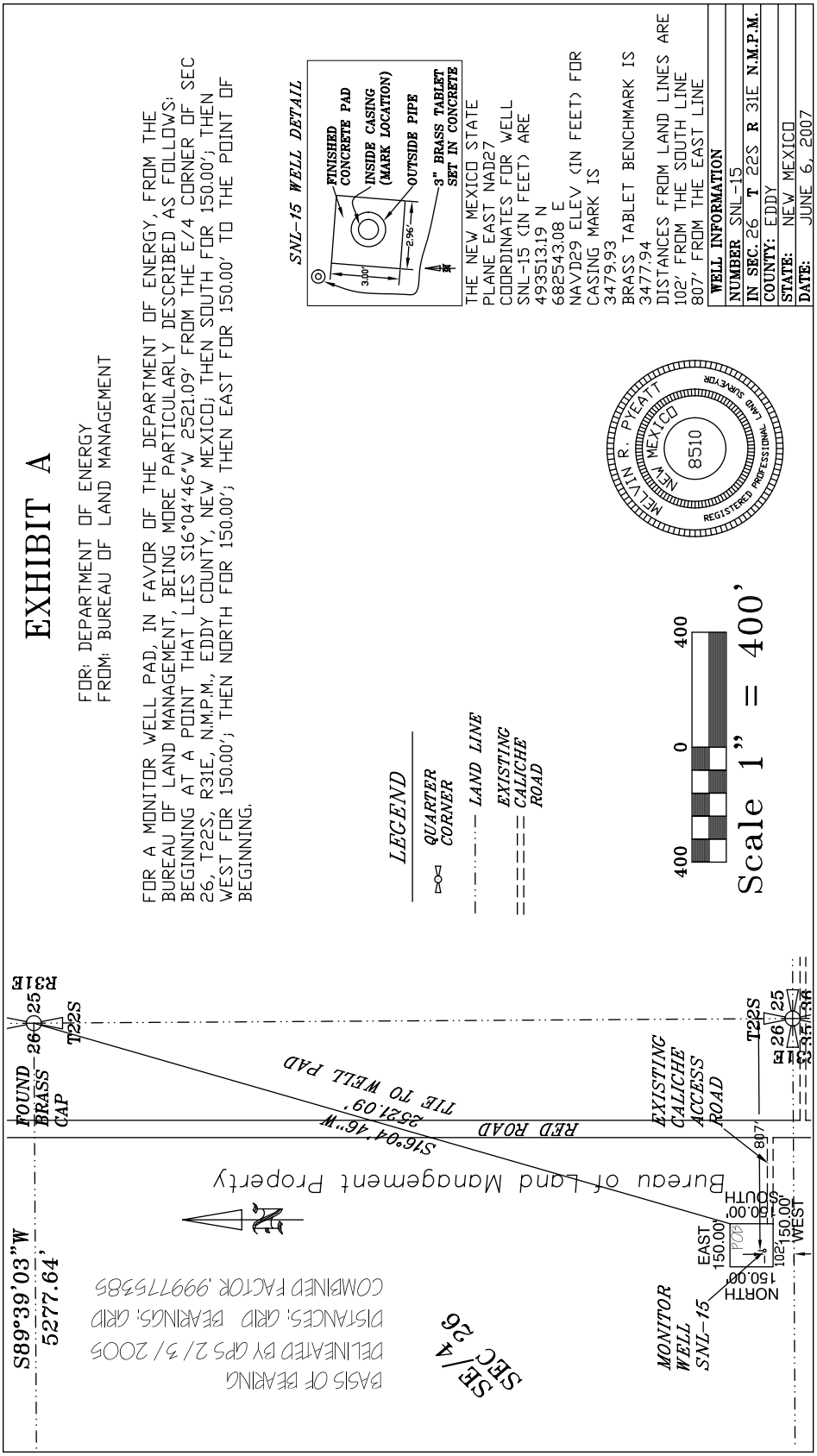


Figure 1-2
Survey Plat
for SNL-15

SNL-15 is to:

1. Provide water-level data in a key area east of the WIPP site;
2. Provide a location for monitoring a large-scale (multipad) pumping test south of WIPP; and
3. Provide a possible location for a slug test of Culebra hydraulic properties.

1.3 SNL-15 Drilling and Completion

The basic information about drilling and completion of SNL-15 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-15 was rotary drilled and cored to a total depth of 950 ft bgl (Fig. 1-3) as measured during drilling. Coring recovery was complete, and the fitted, measured, and marked core was 1.5 ft more than the depth measured during drilling, reaching 951.5 ft. The total depth of the drillhole may be 951.5 ft, as shown by ( ) in some diagrams. For practical purposes, 950 ft is taken as the total depth. The bottom of the hole was plugged before reaming the cored interval to 940 ft and then logging for completion activities. Geophysical logging indicated ~3 ft less depth to stratigraphic contacts in the lower part of SNL-15; geological logs (Appendix C) show greater depths for the Culebra than are indicated by geophysical logs. SNL-15 was drilled using compressed air (two compressors). Cuttings from SNL-15 were of useful size because of these methods.

Core recovery was complete through the Culebra, with recovered lengths slightly exceeding the cored interval as measured during drilling (Table 1-1; Appendix C). Complete core recovery is rare through the Culebra (e.g., Powers, 2002b; Mercer and others, 1998).

In keeping with recent practice at WIPP, SNL-15 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-15 was completed with a single screened interval for monitoring and testing of only the Culebra Dolomite (Fig. 1-4). With a single completion interval, some of the difficulties associated with multiple completions can be avoided: expense of buying, placing, and maintaining packers; loss of water-level data when packers fail; mixing of waters of differing qualities when packers fail; and the increased complexity of testing in a well completed to multiple intervals. If warranted, additional wells can be completed to other intervals, such as the Magenta Dolomite Member of the Rustler Formation, on the SNL-15 wellpad (SNL, 2003).

Geophysical logs, especially the natural gamma and caliper logs, were used to make the final decisions regarding completion of SNL-15 (Fig. 1-4) (Appendices D and E). The drillhole penetrated the uppermost part of the lower Rustler, and HolePlug® was put into SNL-15 to prevent circulation into that interval (Fig. 1-4). The bottom of the Culebra screen interval was placed at 928.5 ft, well above the claystone below the Culebra. The Culebra is thicker than the screen interval; this avoids possible plugging of the lowermost slots and covers higher zones that are generally more porous (Fig. 1-4). The top of the screen, at 902 ft, is at the top of the Culebra. The top of the gravel pack (4/10 silica gravel) at 896 ft is below the level of the mudstone in the Tamarisk to prevent connection to the Culebra. Bentonite (HolePlug®) was placed to 891 ft, and the annulus above the bentonite was cemented to the surface. The caliper log (Fig. 1-3) after the drillhole was drilled to 940 ft at a diameter of 7.875 inches and before the casing was placed shows little sign of drillhole enlargement in the Forty-niner and Tamarisk mudstones or in the mudstone just below the Culebra.

The surface configuration (Fig. 1-5) provides stability, security, and ready access to the casing for measurements, sampling, or other testing. The

Figure 1-3
SNL-15 As-Built Diagram

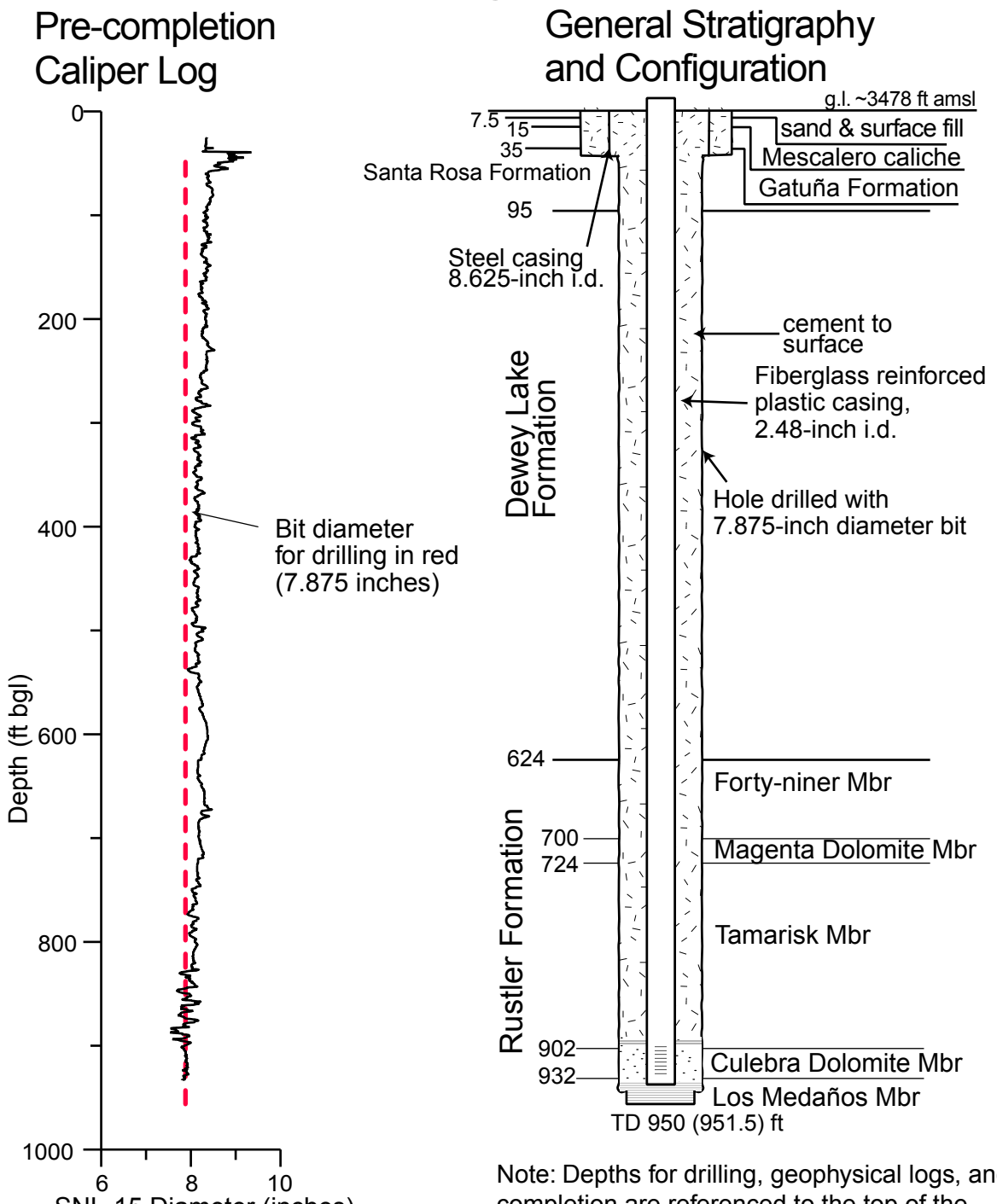


Table 1-1. Summary of Drilling and Well Completion Records for Hydrologic Drillhole SNL-15 (C-3152)

LOCATION: Southeast ¼, Section 26, Township 22 South (T22S), Range 31 East (R31E)

SURFACE COORDINATES: The well is located 102 ft from the south line (fsl) and 807 ft from the east line (fel) of Section 26. The New Mexico State Plane (NAD 27) horizontal coordinates in feet are 493512.95 North, 682542.25 East (Fig. 1-2 shows the survey plat). Universal Transverse Mercator (UTM) horizontal coordinates (NAD27, Zone 13) in meters were calculated for SNL-15 using Corpscon for Windows (v. 6.0): 618352.94 East, 3580336.30 North. Figure 1-1 shows UTM coordinates on a 1,000-m grid.

ELEVATION: All depths used in geological and geophysical data were measured from the top of the connector on the steel surface conductor casing just above the level of the drillpad surface (Fig. 1-5). Depths are reported as below ground level (bgl), which is taken as 3,478 ft above mean sea level (amsl), the rounded value for the brass tablet benchmark (3,477.94 ft amsl) adjacent to the cement well pad. [This is the resurveyed value from the plat in Fig. 1-2; the benchmark has not been replaced (Fig. 1-5) and shows the original embossed value of 3479.22 ft amsl.] The primary datum for the completed well is 3,479.93 ft amsl (NGVD 29) for a mark on the top of the fiberglass reinforced plastic casing inside the protective well pipe. Figures 1-3, 1-4, and 1-5 show the as-built configuration of SNL-15.

DRILLING RECORD:

Dates: Began drilling June 1, 2005; drillhole reached total depth (950 ft) on June 5, 2005. Geophysical logging was conducted on June 6, 2005, after reaming the cored interval. Drillhole was cased and cemented June 7, 2005.

Circulation Fluid: SNL-15 was drilled to TD with circulating air, discharging cuttings into a lined portable steel container. The hole was drilled (and reamed following coring) using a 7.875-inch bit and did not require additional reaming to complete.

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

900.0–950.0 (951.5 bottom of marked core) ft bgl: lower Tamarisk, Culebra Dolomite, and upper Los Medaños Members

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

Table 1-1. Summary of Drilling and Well Completion Records For Hydrologic Drillhole SNL-15 (C-3152), continued.

Drillhole Record:

Size (inches)	From (ft bgl)	To (ft bgl)
12.75	0	39.5
7.875	39.5	940
6.75	940	950

Casing Record:

Outside diameter (inches)	Inside diameter (inches)	Weight/ft (pounds)	From (ft bgl)*	To (ft bgl)
8.625	8.125	22.36 steel	-0.5	39.5
2.880	2.480	1.75 FRP** blank	-2.0	902.00
2.880	2.480	1.75 FRP screen	902.00	928.5
2.880	2.480	1.75 FRP blank	928.5	935.0

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

**FRP: fiberglass reinforced plastic; specifications for SP2000 FRP tubing have changed since SNL-15 was completed

Coring Record:

Core Run No.	Depth Interval (ft) From	To	Interval (ft) Cored	Recovered	Recovered %
1	900	927	27	27.4	101.48%
2	927	950	23	24.1	104.78%
		Totals	50	51.5	103.00%

Figure 1-4
SNL-15 Completion and Monitoring Configuration (6/7/05)

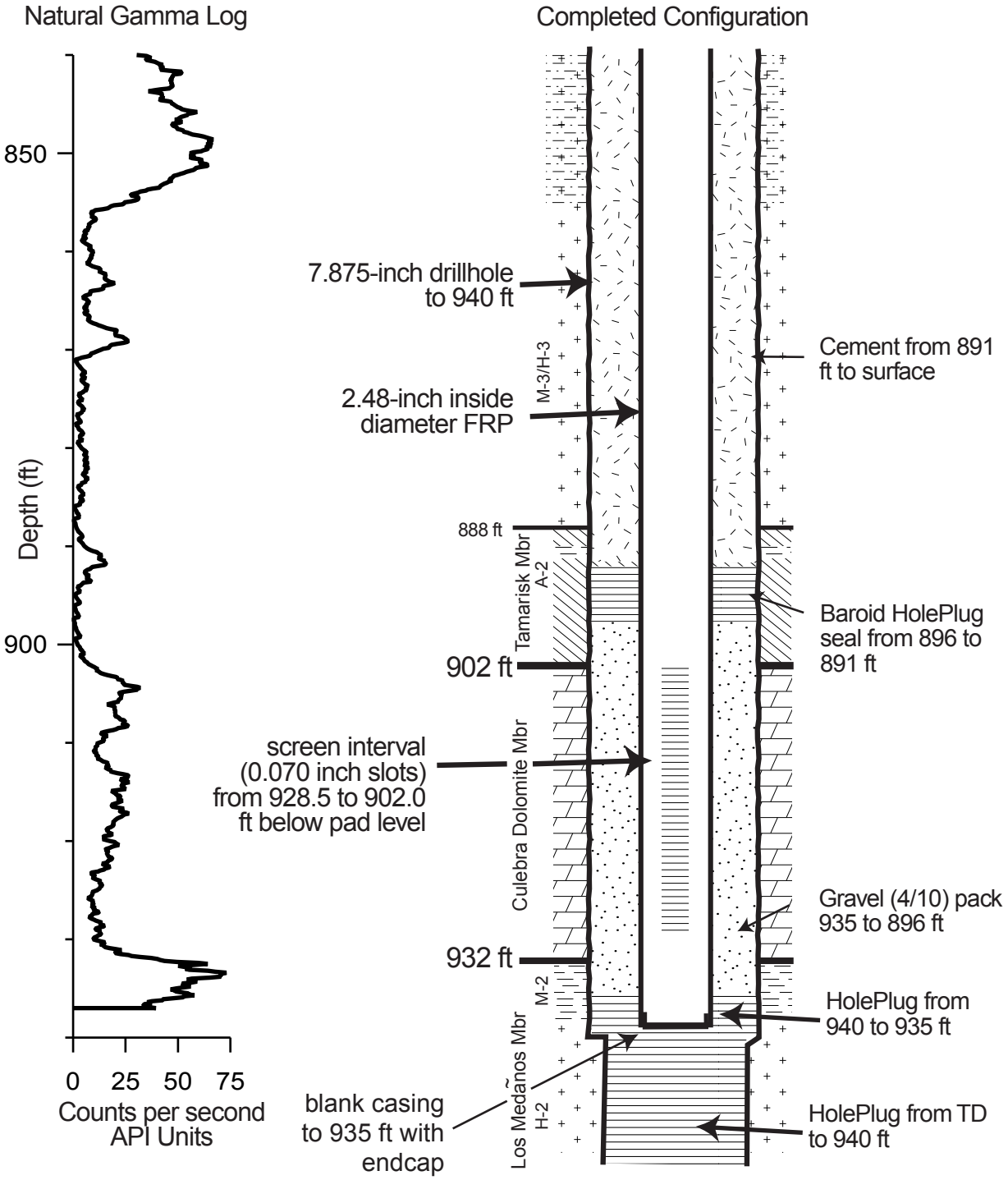
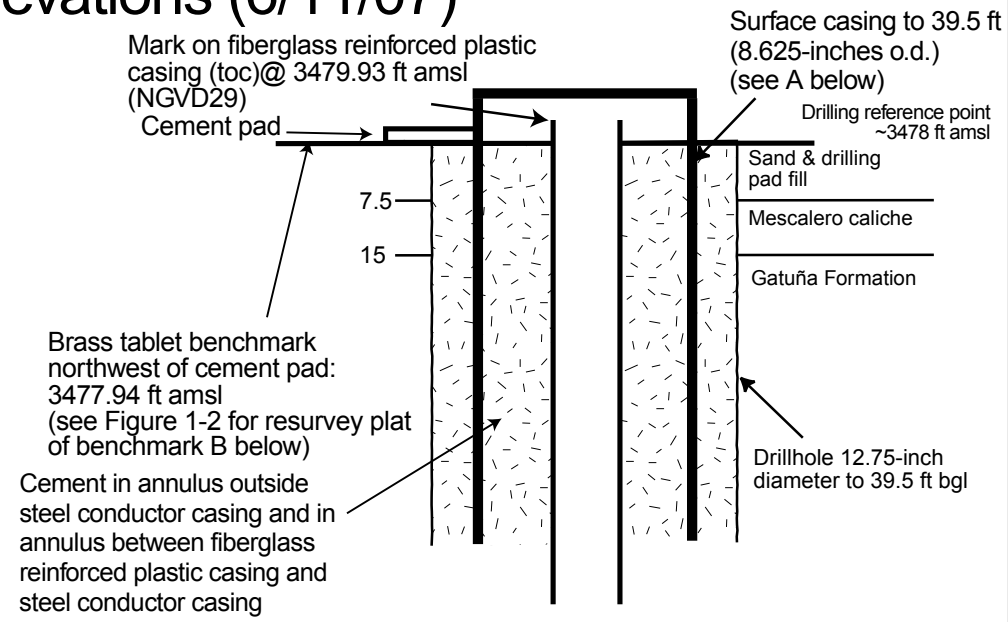
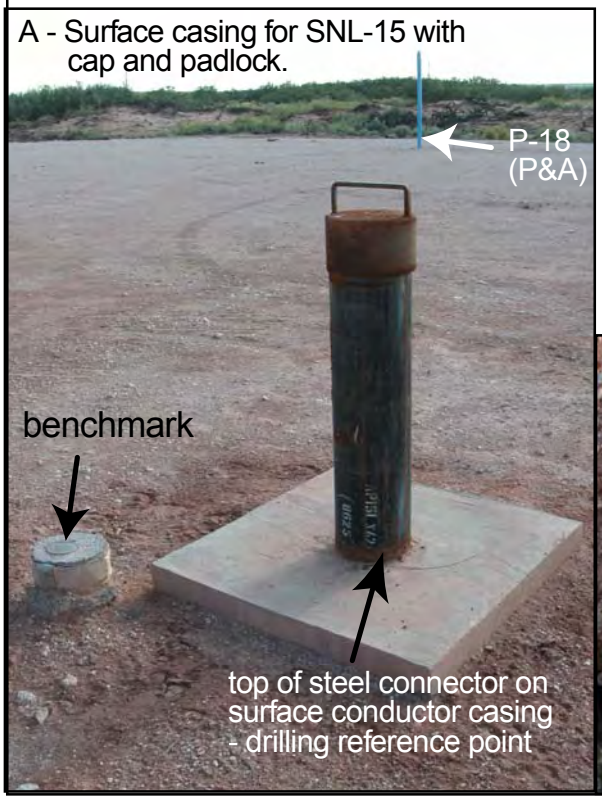


Figure 1-5
SNL-15 Surface Configuration and Elevations (6/11/07)





Note: Depths of shallow units are based on cuttings collected at intervals, and contacts are arbitrarily assigned between sample depths

Note: benchmark was punched with an elevation of 3479.21 ft amsl based on original survey.

surface benchmark is an accessible reference point for future measurements if the well configuration is changed.

A steel surface conductor casing was cemented in place to a depth of 39.5 ft below the surface, with the top of the steel connector on the 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 3,479 ft amsl, based on a pre-drilling survey of the well pad. The benchmark placed at the drilling pad surface next to the completed well has an elevation of 3,477.94 ft amsl (after resurvey 2007) and is very close to the elevation of the connector on the casing. *Other than water-level monitoring, depths are stated as bgl, and the top of the steel connector on the surface conductor casing is taken as a proxy reference point for ground level with an elevation of ~3,478 ft amsl (Figs. 1-3, 1-4, and 1-5).* The FRP casing projects ~2 ft above the steel connector on top of the conductor casing. This FRP casing point is surveyed (Fig. 1-5), and it provides the reference point and reference elevation (3,479.93 ft amsl; after resurvey, 2007) for monitoring water levels.

1.4 Other Background

SNL-15 was drilled and completed by the West Texas Water Well Service, 3410 Mankins, Odessa, Texas, under contract from Washington TRU Solutions LLC (WTS). Coring was done by John Wood, Diamond Oil Well Drilling Co., Inc., P.O. Box 7843, Midland, Texas. Geophysical logging was conducted by Al Henderson, Jet West Geophysical Services, LLC, 2550 La Plata Highway, Farmington, NM, 87499-3522, under contract to West Texas Water Well Service. Geological support was provided by Dennis W. Powers under contract to WTS. Mike Stapleton of the New Mexico Office of the State Engineer witnessed hole completion activities (Appendix D). Well drilling wastes (cuttings) were removed from SNL-15 and disposed of at the Lea Land, Inc., landfill north of WIPP. Archeological clearances obtained from the U.S. Bureau of Land Management were based on field work and reports by Mesa Field Services, Carlsbad, New Mexico (Appendix E). Cores from SNL-15 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 (weak red: 5YR5/4) included in the text and Appendix C are based on the 1971 edition of the Munsell Soil Color Charts. The names may differ from the general color observed; the rocks are compared when dry unless otherwise specifically noted.

1.5 Acknowledgements

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

2.0 GEOLOGICAL DATA

2.1 General Geological Background

The geology and hydrology of formations at the WIPP site and surroundings have been intensively investigated since 1975, and the information and interpretations have been reported in numerous documents. The most thorough compilation is certainly the Compliance Certification Application (CCA) submitted in 1996 by the DOE to the EPA (U.S. DOE, 1996). Some salient features of the broader geological history, as well as more recent work on the geohydrology of the Rustler (e.g., Holt and Yarbrough, 2002; Powers, 2002a, 2003a; Powers and others, 2003), are relevant to understanding the geology and hydrology at SNL-15.

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

2.2 Geological Data From SNL-15

SNL-15 encountered a normal stratigraphic sequence from ground level to total depth for this location east of the WIPP site area, (Fig. 2-1; Table 2-1). Units encountered ranged from unconsolidated surficial alluvium to the upper part of the Los Medaños Member of the Permian Rustler Formation. Structural, sedimentological, and diagenetic features were examined during investigation using cuttings, cores, and geophysical logs. Details of the sedimentology of the Rustler will extend understanding of that unit. There was no noticeable water produced from any unit, including the Culebra, during drilling.

The geologic units encountered in SNL-15 are described from total depth to the surface, in the order in which they were deposited rather than in the order in which they were encountered in the drillhole. Cores and cuttings were described in the field using mainly drilling depths for depth control. Geologic logs detailing field observations of cuttings and cores are included in Appendix C. The difference between geophysical logs and drilling depths is generally slight. The largest differences between depths determined by geophysical logging and core markings based on depths measured during drilling is approximately 3 ft through lower units in SNL-15. Decisions about placing screen intervals and annulus fillings were based on depths indicated by geophysical logs (Appendix G).

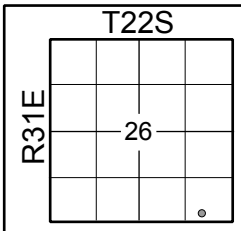
Note that the descriptions that follow use depths that correspond to core markings, with basic stratigraphic intervals provided by geophysical logs, as indicated.

2.2.1 Permian Rustler Formation

The Rustler was drilled and cored into the upper Los Medaños Member. The contact between the Rustler and the overlying Dewey Lake Formation is at 624 ft (Fig. 2-1), and 326 ft of the Rustler were penetrated at SNL-15 (Table 2-1).

Figure 2-1
Well Record SNL-15 (C-3152)

Company: Washington TRU Solutions LLC
Well: SNL-15 (C-3152)
Section: 26 Twp: T22S Rge: R31E
Location: 102 ft from south line (fsl)
807 ft from east line (fel)



Reference point
Log measured from: top of connector on conductor casing (gl)
Drilling measured from: gl
Permanent Datum: benchmark (resurveyed 2007)

Elevation
KB:
DF:
GL: 3478 ft amsl
(benchmark: 3477.94)

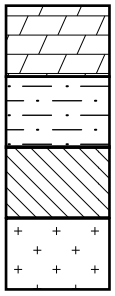
Drilling contractor: West Texas Well Water Service
Coring contractor: Diamond Oil Well Drilling Co.
Geophysical logs: Al Henderson
Jet West Geophysical Services, LLC (NM)
Geologist: Dennis W. Powers
Spud date: June 1, 2005
Completion date: June 7, 2005
Total depth (TD): 950 ft bgl (driller log)

Casing Record
Conductor: 40 ft
8.625 inch steel
Casing: 2.48 inch i.d.
fiberglass reinforced
plastic to 935 ft bgl
Screened interval:
928.5-902 ft bgl

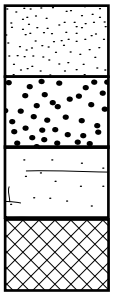
Geophysical Logs Date: June 6, 2005
Micro/Laterolog/Induction/SP: 0-936 ft
Gamma/Fluid: 0-936 ft
Caliper: 0-934 ft
Density/Neutron: 0-938 ft

Type fluid in hole: air
Res mud: n/a
Res mud filtrate:
n/a
Max. Rec. Temp.:
not recorded

General Lithologic Symbols Used

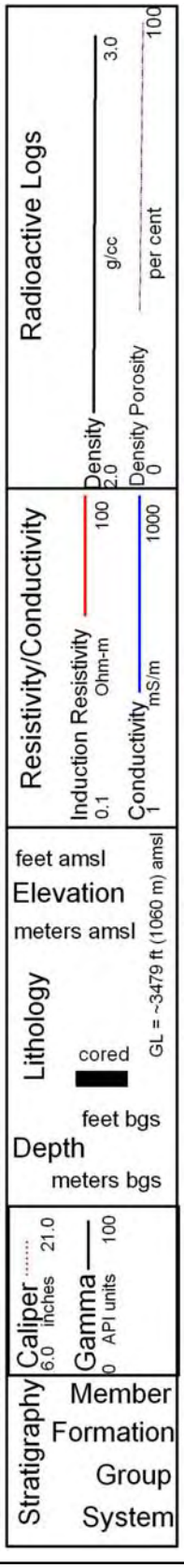


Dolomite
Mudstone/siltstone
Anhydrite
Halite



Fine sandstone & siltstone
Coarse sandstone
Sandstone w/caliche
Polyhalite

SNL-15 Well Log Headers



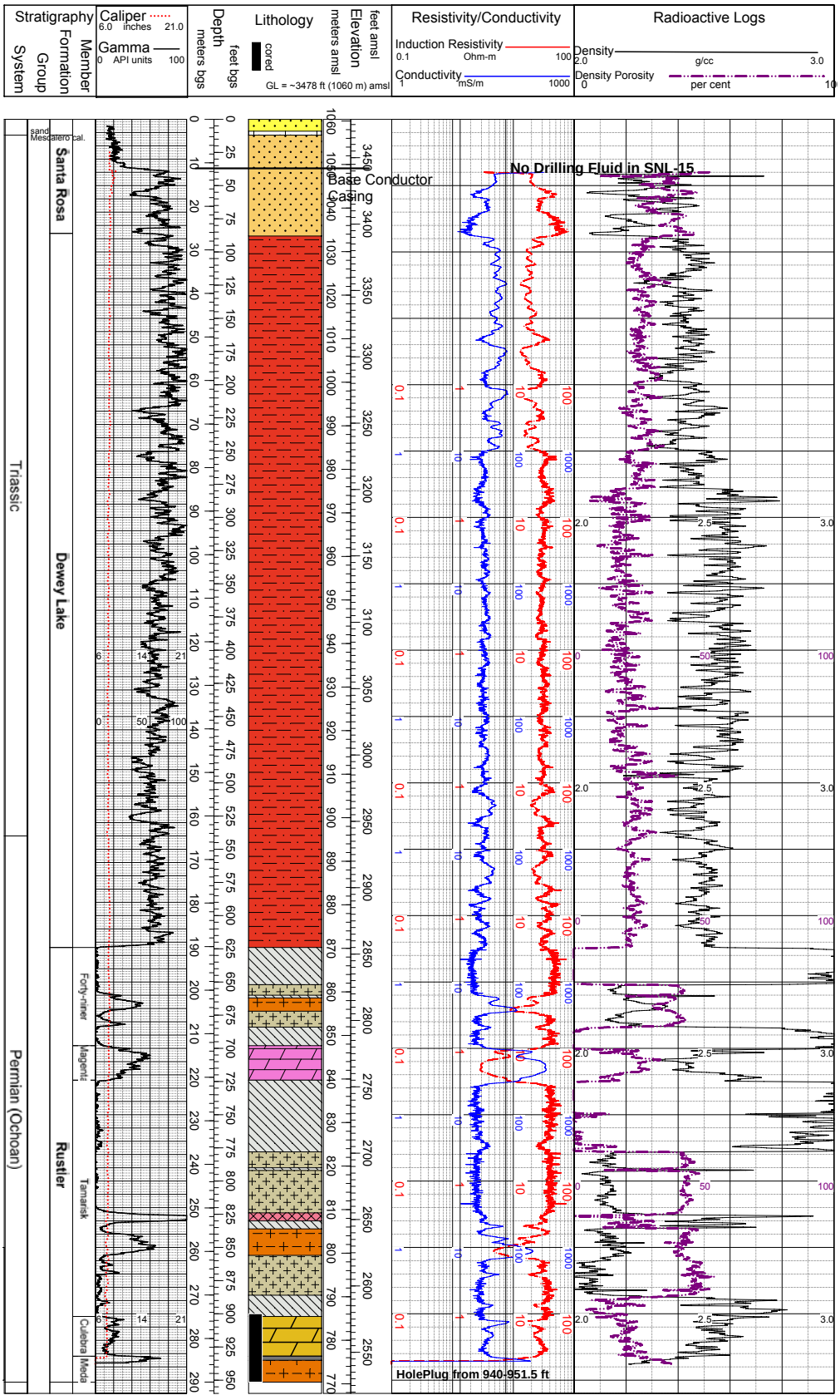


Figure 2-1, continued.

(see Appendix G for larger format log)

Table 2-1
Geology at Drillhole SNL-15

System/ Period/Epoch		**Formation or unit**	**Member** *Informal units*	**Depth below surface (ft)**[1]
Cenozoic	Holocene	surface dune sand and pad fill		0 - 7.5 ft
	Pleistocene	Mescalero caliche		7.5 - 15 ft
	Miocene-Pleistocene	Gatuña		15 ft - 35 ft
Mesozoic	**Triassic**	Santa Rosa[2]		35 ft - 95 ft
		Dewey Lake[3]		95 ft - 624 ft
Paleozoic	**Permian**	Rustler	Forty-niner *A-5* *M-4/H-4* *A-4*	624 ft - 700 ft *624 ft - 652 ft* *652 ft - 684 ft* *684 ft - 700 ft*
			Magenta Dolomite	700 ft - 724 ft
			Tamarisk *A-3* *M-3/H-3* *A-2*	724 ft - 902 ft *724 ft - 778 ft* *778 ft - 888 ft* *888 ft - 902 ft*
			Culebra Dolomite	902 ft - 932 ft
			Los Medaños[4] *M-2/H-2*	932 ft - 951.5 ft *932 ft - 951.5 ft (TD)* [5]

[1]Depths are based on measurements by geophysical logging; drilling and coring provided supplemental data to total depth (TD) of 950 ft bgl by driller's log and 951.5 ft as marked on core. Geophysical logs and drilling/coring depths begin at the top of the connector on the surface steel conductor casing. This reference point is taken as 3,478 ft amsl; it is near the elevation of the surface benchmark adjacent to SNL-15. Water level depths will be measured and reported relative to the surveyed point on the top of the fiberglass reinforced plastic casing (Fig. 1-5). Geological logs based on field descriptions (Appendix C) and markings on cores (Appendix G) vary modestly from log depths, mainly in the lower part of SNL-15.

[2]The Santa Rosa Formation, part of the Dockum Group or undifferentiated Triassic, is present at SNL-15, although it commonly is eroded west of the center of the WIPP site.

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

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

[5]The driller's total depth was 950 ft. The core recovered from 900–950 ft totaled 51.5 ft, and the lowest marked core is at 951.5 ft.

2.2.1.1 Los Medaños Member

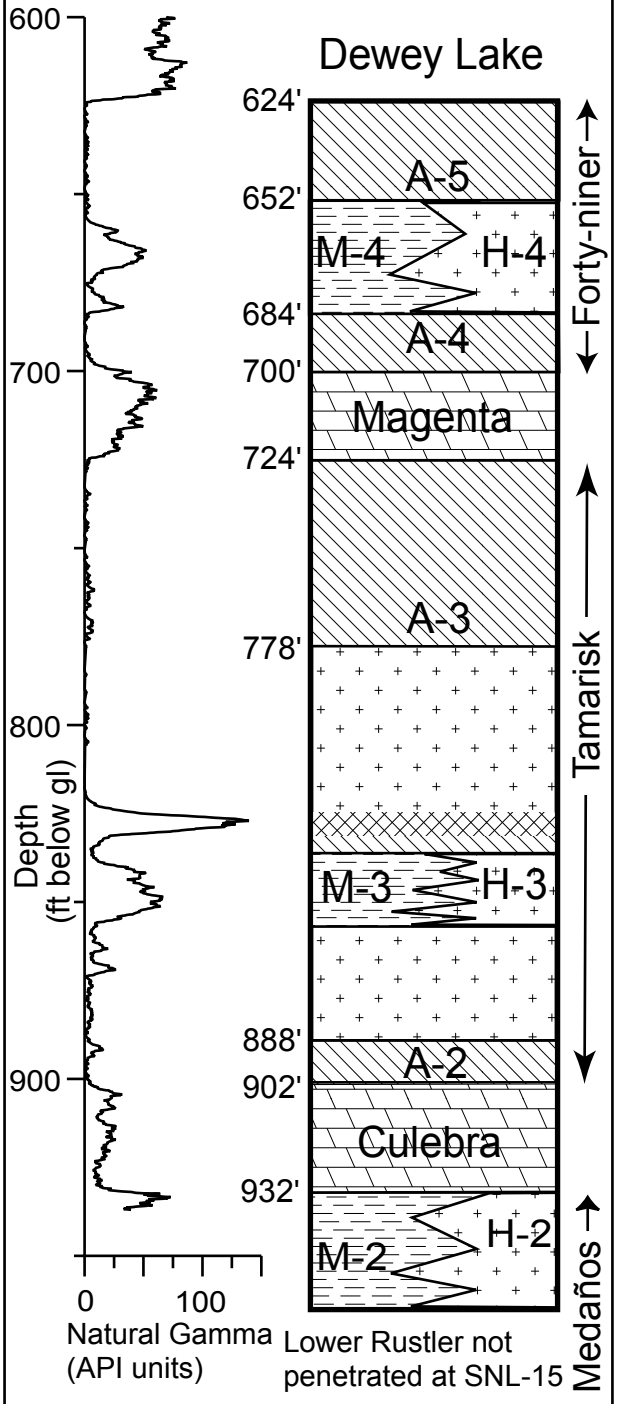
The Los Medaños was named by Powers and Holt (1999) based on the rocks described in shafts at the WIPP site. For the area around WIPP, studies of the Rustler have commonly referred to this interval from the base of the Culebra Dolomite Member to the top of the Salado Formation as the unnamed lower member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

The upper part of the Los Medaños was cored (16.1 ft) in SNL-15, penetrating into halite facies (H-2) of M-2/H-2, but not reaching A-1.

The informal unit *mudstone-halite 2* (M-2/H-2; Fig. 2-2) was encountered from 935.4–951.5 ft bgl, based on coring depths, and recovery was complete. The natural gamma log shows the top of M-2/H-2 at 932 ft (Fig. 2-1). The basal contact with A-1 was not penetrated. The contact between M-2 and Culebra was recovered as continuous core, and the contact is sharp and undeformed.

From 938.7–951.5 ft, the core is clear halite that appears gray to slightly orange. Crystals are fine to very coarse, up to 1.5 inches across. Variable amounts of reddish brown (5YR5/4) silty claystone form irregular beds and zones as well as filling interstices between crystals (Fig. 2-3). Although halite shows displacive boundaries in mud in some zones, other halite margins are somewhat more irregular. There is some halite that incorporates mud. A few thin planes may be corrosion surfaces from exposure to fresher water inflows within the salt pan. From 943.3–945.5 ft, the halite is sulfatic, and some of the sulfate is likely polyhalite.

Figure 2-2
Rustler Units at SNL-15



Formal and informal Rustler Formation units and depths at SNL-15 based on natural gamma log in combination with density logs that help identify halite intervals.

Figure 2-3. Coarse Halite with Reddish-Brown Mudstone, Upper H-2

Thin, silty claystone at 938.2 ft overlies a very thin sulfate and includes probable claystone clasts. Some thin sulfate marks the boundary with gray claystone.

The upper 2.9 ft of M-2 consists of gray (5Y5/1) to dark gray claystone (5Y4/1) (Fig. 2-4) that shows evidence of thin bedding and laminae that are approximately horizontal. A narrow fracture from 936–937 ft is filled with gypsum and, possibly, halite. Slickensides in some of the claystone are ~50 degrees from horizontal. The contact at 935.4 ft with the Culebra is sharp and undeformed.

2.2.1.2 Culebra Dolomite Member

Based on the natural gamma log from SNL-15, the Culebra extends from 932–902 ft bgl, a thickness of 30 ft (Fig. 2-1). Based on drilling depths available at the time, the recovered Culebra core was marked from 935.4–904.9 ft bgl (as used in information in Appendices C and F). Recovered Culebra core (Fig. 2-5) totals 30.5 ft thick, and this represents all of the unit.

Holt and Powers (1988) found a range of 20–30 ft thickness in Culebra cores described from the WIPP Project, and a regional thickness exceeding 40 ft, based on geophysical log data. Significant core loss in the middle of the Culebra is common. Complete recovery of core at SNL-15 is likely due to the lack of porosity and the halite that fills a few fractures as well as some pore space. Drilling using compressed air may also have contributed to complete recovery.

The dolomite recovered in core from SNL-15 is generally light gray (5Y7/2) to pale yellow (5Y8/3). The Culebra at SNL-15 is thin bedded to laminar (Fig. 2-5). No open vugs were observed. Nodules are variable in size, ranging to ~2 inches, and are distributed through the unit. Nodules were composed of anhydrite with some probable gypsum. Some pore space associated with nodules also was filled with halite (Fig. 2-6). Very tiny filled pores or spheres appear to be distributed through the lower Culebra, but they are difficult to interpret or describe because they are visible

Figure 2-4. Gray Claystone (M-2) and Overlying Culebra Dolomite

in part in a patina or case-hardened surface of the core.

Subvertical fractures occur mainly between ~917 and 925 ft, and they are filled with halite (Fig. 2-7). The fractures generally have separations less than 0.25 inch.

The hydrostratigraphic units proposed for the Culebra by Holt (1997) are less obvious in the SNL-15 core, and they may not be represented so clearly because features of these units are partly expressed by diagenesis that has not occurred at this location.

The most likely equivalent to the basal CU-4 hydrostratigraphic unit occurs from 933–935.4 ft. It has bedding, is fine-grained, and does not exhibit much in the way of filled pores. In the WIPP site area, including H-19, this zone shows some fracturing, and the basal contact is usually slightly deformed by fracturing.

From 926–933 ft, the Culebra shows thin (~0.25 inch) laminar zones spaced at 2–6 inches and abundant small pores (~0.06 inch). A few pores up to ~0.5 inch are scattered through the interval. This interval is tentatively correlated with CU-3 (Holt, 1997).

From 911–926 ft, the dolomite displays more laminar bedding, and larger sulfate-filled vugs, up to ~2 inches, are common but not abundant. Some bedding-plane separations occur along darker organic- or clay-rich laminae. In addition, there are several halite-filled fractures within the lower half of this zone. The fracture between 917 and 918 ft shows some staining as well as halite filling (Fig. 2-7); this fracture might have some open porosity within the formation. This is likely the most porous section of the Culebra. The entire interval is tentatively assigned to CU-2 (Holt, 1997).

From 911–904.9 ft, the dolomite is fine-grained, silty, thin bedded to laminar, with organic-rich laminae in the upper part and gypsum nodules at the top. Vugs are limited and large (to 2 inches). This interval tentatively corresponds to CU-1 (Holt, 1997).

Figure 2-5 Culebra Dolomite Member of the Rustler Formation at SNL-15

Photo scales vary slighty due to cropping

Figure continued next page

Figure 2-5 continued

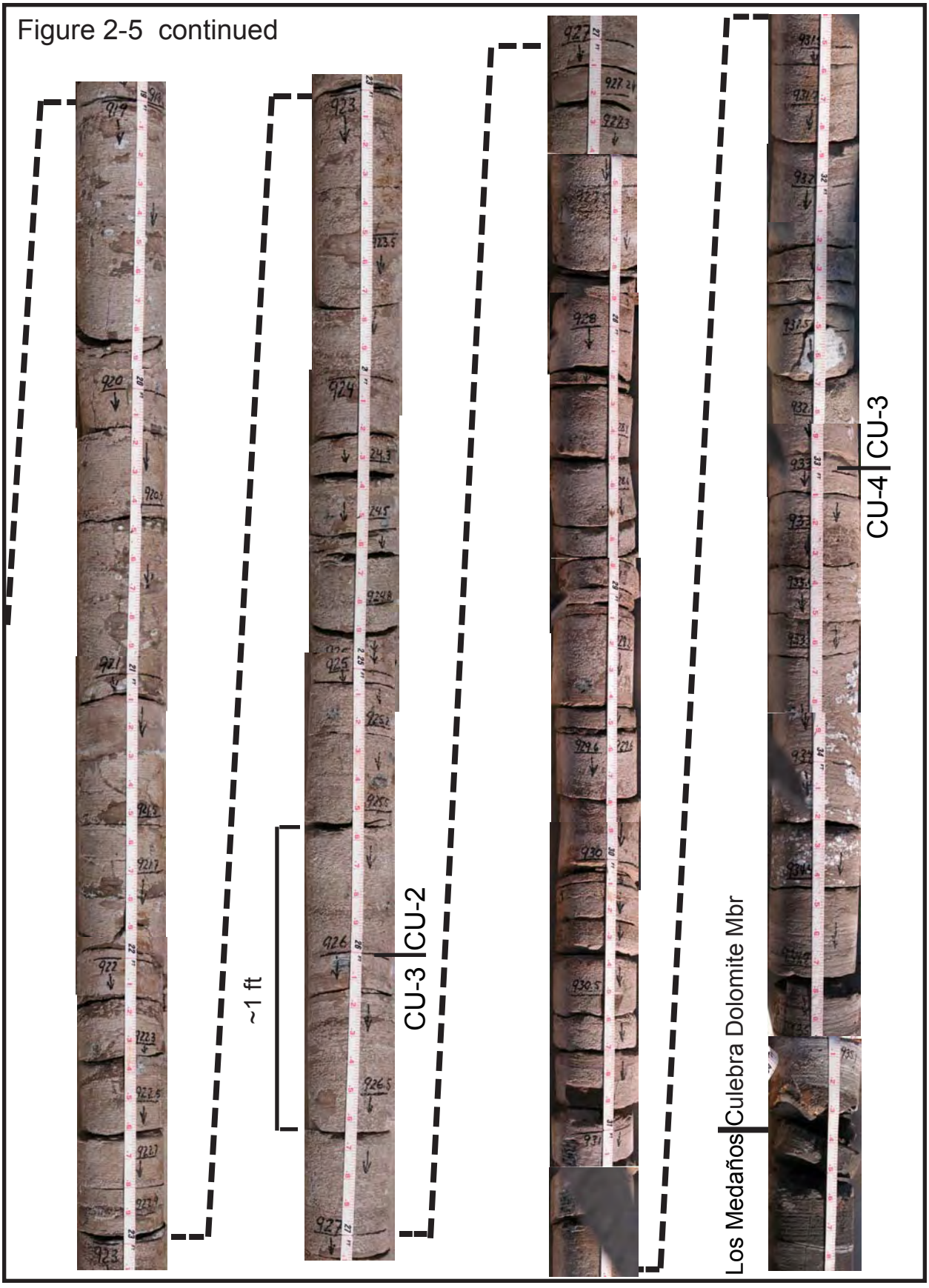


Figure 2-6. Halite on Fracture in Culebra Dolomite. The fracture shows black staining under the clear halite that coats much of the surface. Core has a 4-inch diameter.

Figure 2-7. Halite in Culebra at 907.8 ft. Halite (dark, clear crystals) is filling voids associated with nodules and fine fractures. Core is 4 inches across.

The geophysical logs (Fig. 2-1) of the Culebra provide few additional details of the unit. The natural gamma shows a low from 909–913 ft, which is taken to correspond to the upper part of the core believed to represent upper CU-2. Resistivity remains generally high through the Culebra, with two somewhat reduced resistivity zones (905–910 ft and 914–918 ft, log depths). These correspond to ~909–914 ft and 918–922 ft core depths, based on the differences between depths at the top and base of Culebra. The upper zone includes the inferred CU-1 and CU-2 boundary, with the most strongly expressed laminar bedding and some bedding-plane separations. The lower zone of lower resistivity coincides with the most fractured Culebra interval, even though fractures tend to have halite fillings. Overall, there is not a great contrast in log properties through the Culebra, and the Culebra is not likely to have either high porosity or high transmissivity based on log and core observations.

2.2.1.3 Tamarisk Member

The natural gamma log of SNL-15 shows that the Tamarisk occurs from 724–902 ft bgl. The Tamarisk comprises three basic subunits: a lower anhydrite, a middle halite and mudstone, and an upper anhydrite; all three are clearly shown by geophysical logs and were recorded by cuttings during drilling. Powers and Holt (2000) labeled these A-2, M-3/H-3, and A-3, respectively, and showed that the lateral gradation from mudstone M-3 to halite H-3 generally reflects lateral changes in deposition. SNL-15 is located mainly in the saltpan or H-3 facies of these beds, although the natural gamma also indicates an argillaceous or muddy zone. The basal 4.9 ft of the Tamarisk was 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 14 ft thick (888–902 ft) based on the geophysical logs. The cored interval from 900.0–904.9 ft is predominantly dark gray anhydrite with some gypsum. It is generally fine to medium crystals, with clear gypsum in pores, including sulfate needles that precede cements. There may be some halite pore fillings. Thin beds and thin laminae are visible, and the core is purplish from 904.2–904.6 ft.

The informal Tamarisk unit *mudstone-halite 3* (M-3/H-3; Fig. 2-2) at SNL-15 is 164 ft thick (724–888 ft bgl), based on the natural gamma log. Halite (H-3) dominates this informal unit at SNL-15.

The geophysical log (Fig. 2-1) for M-3/H-3 illustrates subdivisions described by Holt and Powers (1988). They divided H-3 at the sulfate bed near the middle of H-3 into a lower H-3a and an upper H-3b. H-3a can be further subdivided into a lower clean halite, middle argillaceous halite, and upper clean halite below the sulfate bed. H-3a here at SNL-15 only exhibits the lower clean halite and middle argillaceous halite, similar to other drillholes (e.g., H-12; Holt and Powers, 1988) away from the middle of the halite salt pan.

The density log indicates higher density sulfate dominates from 824–836 ft, with some possible thin interbeds of halite. The upper part of the sulfate has higher natural gamma and corresponds to polyhalite that is persistent through much of the depositional basin east of the WIPP site.

H-3b at SNL-15 has very low natural gamma, indicating little clay or clastic material. A thin anhydrite from 791–792 ft is also consistent with units that are persistent through the deeper part of the depositional basin east of WIPP.

A-3 was not cored. Cuttings indicate gray to dark gray anhydrite. The density log shows the unit is 54 ft (724–778 ft) thick and persistently high density with well-defined contacts.

2.2.1.4 Magenta Dolomite Member

Based on geophysical logs, the Magenta at SNL-15 is 24 ft thick (700–724 ft). This is

a normal thickness for the member. Cuttings from the unit ranged from fine powder to small chips with a grayish-purple hue (2.5YR5/2; weak red).

Geophysical log data from the Magenta show lower density than the adjacent anhydrite beds. Resistivity is much lower through the Magenta than in adjacent beds. These responses may indicate halite and some porosity with a little brine. Gypsum is not favored in the presence of halite, which exists in overlying and underlying members.

2.2.1.5 Forty-niner Member

Based on geophysical logs, the Forty-niner at SNL-15 is 76 ft thick (624–700 ft). The Forty-niner is described on the basis of cuttings and geophysical logs. Like the Tamarisk, the Forty-niner consists of upper and lower anhydrites with a middle unit that includes halite at SNL-15. Powers and Holt (2000) informally designated these units as A-4, M-4/H-4, and A-5, from bottom to top. They attributed the lateral relationship between clastic beds (M-4) and halite (H-4) to depositional facies of mudflat–saline mudflat–saltpan environments.

The lower unit, *anhydrite 4* (A-4; Fig. 2-2), is gray anhydrite; cuttings include some clear halite that is from the overlying unit. A-4 is 16 ft thick (684–700 ft), based on geophysical logs, and contacts are sharp.

Mudstone-halite 4 (M-4/H-4; Fig. 2-2) is about 32 ft thick (652–684 ft), based on the natural gamma and density log. Cuttings and geophysical log data indicate that H-4 predominates, with lower and upper clean halite with a middle more argillaceous reddish-brown zone. A thin anhydrite occurs from 660–662 ft.

The upper sulfate unit, *anhydrite 5* (A-5), is gray (5YR6/1) fine anhydrite that is 28 ft thick (624–652 ft bgl) at SNL-15. The upper contact with the Dewey Lake Formation is sharp.

2.2.2 Permo-Triassic Dewey Lake Formation

The Dewey Lake Formation has most commonly been assigned to the Permian System (e.g., Hills and Kottlowski, 1983), although there is no direct evidence, either paleontological or radiometric, of age in the vicinity of WIPP. More recently, Renne and others (1996, 2001) obtained radiometric (Ar-Ar) ages from ash beds near the base of lithologically equivalent red beds (Quartermaster Formation) in the Texas panhandle. These ages show that the basal Quartermaster is Permian, but most of the formation is early Triassic in age. Although lithologic contacts are not inherently isochronous, the particular relationships of evaporites to red beds suggest that the Dewey Lake is mainly Triassic in age (e.g., Schiel, 1988, 1994; Powers and Holt, 1999). Lucas and Anderson (1993) have asserted that the Quartermaster, and Dewey Lake, are Permian in age, but more recent direct evidence supersedes their discussion.

At SNL-15, the Dewey Lake is 529 ft thick (95–624 ft bgl) and is composed mainly of reddish-brown (2.5YR4/4 to 5/4) interbedded sandy siltstone, argillaceous siltstone, and fine-grained sandstone. Small white reduction spots and zones are a common characteristic of the Dewey Lake and are recorded by the cuttings at SNL-15. The Dewey Lake is generally moderately well indurated. It is slightly calcareous near the top but shows no evidence of carbonate deeper in the formation. Below 210 ft, Dewey Lake cuttings include gypsum, and there is some macroscopic indication of gypsum cements below this depth. The Dewey Lake is described on the basis of cuttings, drilling rates, and geophysical log characteristics.

Geophysical logs from SNL-15 can be interpreted to indicate different basic sedimentary regimes as well as porosity conditions (e.g., Doveton, 1986). The following information follows the basic template developed for

a study of the Dewey Lake hydrogeology (Powers, 2003b) and applied to other drillholes such as C-2737 (Powers, 2002b) and SNL-2 (Powers and Richardson, 2004).

All three general depositional regimes for the Dewey Lake Formation can be distinguished on natural gamma logs of SNL-15.

The interval from 530–624 ft bgl in SNL-15 displays the natural gamma features of the lower Dewey Lake informally called the *basal bedded zone* (Powers, 2003b). Resistivity is, however, not helpful in differentiating the lower two units. The natural gamma fluctuates around a similar value (~70–100 cps in this case) over this vertical interval. A short low in natural gamma indicates the top of the zone.

The interval from 174–530 ft bgl (356 ft thick) is marked by generally upward-increasing gamma above thinner low-gamma units. These are interpreted as an interval of *fining-upward cycles* because increasing natural gamma is frequently an indicator of finer clastic grain sizes (Doveton, 1986; Powers, 2003b). The base of this interval is defined by sandstone from ~522–530 ft. Near the center of the site, this interval is more than 300 ft thick; at C-2737 it was 260 ft thick (Powers, 2002b). West-southwest of WIPP, sandstones of the upper fining-upward cycles are removed by erosion.

Above 174 ft, natural gamma decreases, consistent with coarsening upward proposed by Powers (2003b). The contact with the Santa Rosa at 95 ft is placed where interbedded sandstones and siltstones begin to dominate.

The natural gamma log through the fining-upward cycles shows zones of decreased intensity over intervals from 216–222 ft and 250–258 ft, likely corresponding to very fine to medium-grained sandstones found across the site area (Powers, 2003b). The sand grains from the lower unit are typically subangular to well-rounded and include few opaque grains. This unit corresponds to sandstone 1 (*ss1*), a persistent sandstone in this stratigraphic interval (Powers, 2003b). The upper sandstone is less persistent.

There is a decrease in resistivity above 250 ft that roughly coincides with the first observed gypsum in cuttings. Cuttings above this zone did not indicate the presence of carbonate, and it is possible the zone above 250 ft is also partially cemented by sulfate. The resistivity change is ~374 ft above the top of the Dewey Lake. This is stratigraphically higher in the Dewey Lake than at C-2737 (Powers, 2002b), where the boundary between sulfate and carbonate coincides with the resistivity change.

From resistivity (Fig. 2-1) and by comparison with other drillholes, the Dewey Lake is likely to be more transmissive above ~250 ft, but there were no indications of water during drilling.

2.2.3 Triassic Santa Rosa Formation

The Santa Rosa at SNL-15 is ~60 ft thick (35–95 ft). It is mainly interbedded siltstone and sandstone that is moderately indurated and ranges from yellowish red (5YR6/6) to light reddish-brown (5YR6/4). The sandstone includes mica and coarser grains in the lower part of the formation.

2.2.4 Miocene-Pleistocene Gatuña Formation

The Gatuña is ~20 ft thick (15–35 ft). It is mainly very calcareous sandstone, ranging from red (2.5YR5/6) to pink (5YR7/3). The sandstone includes ~1% dark opaque grains and some manganese oxide stains, which is similar to findings in broader studies of the Gatuña (Powers and Holt, 1993).

2.2.5 Pleistocene Mescalero Caliche

The Mescalero is an informal soil stratigraphic unit defined by Bachman (1973). It is widespread in southeastern New Mexico, and it is a continuous stratigraphic unit at the WIPP site. Uranium-disequilibrium ages indicate the Mescalero formed as a pedogenic

unit between ~570,000 (± 100,000) and about 420,000 (±60,000) years ago (Rosholt and McKinney, 1980). The age is further bounded by the Lava Creek B ash, about 600,000 years old, which underlies the Mescalero along Livingston Ridge (Izett and Wilcox, 1982).

At SNL-15, the Mescalero is up to 7.5 ft thick (7.5–15 ft) based on shallow cuttings samples. The Mescalero is a white, very calcareous sandstone to sandy limestone. Sand grains were fine to medium, subangular to subround.

Bachman and Machette (1977) classified six useful stages of pedogenic calcrete development, ranging from I as the least developed to VI morphologies showing multiple generations of calcrete development. ("Pedogenic calcrete" is preferred by many geologists and pedologists over the term "caliche" because of the wide variation in use of the latter term.) The Mescalero could not be classified at SNL-15.

2.2.6 Surficial Deposits

Construction fill and sand is up to 7.5 ft thick at the drillhole location. The sand is weak red (2.5YR4/2), friable, and subround to round. The Berino soil (Chugg and others, 1971) was not established at SNL-15.

3.0 PRELIMINARY HYDROLOGICAL DATA FOR SNL-15

SNL-15 was drilled specifically to monitor water levels from the Culebra Dolomite Member of the Rustler Formation and to serve as a location for observations during pumping tests.

3.1 Checks for Shallow Groundwater Above the Rustler Formation

The hole was drilled with compressed air, and there were no indications of water inflow or accumulation above the Rustler during drilling.

3.2 Initial Results From the Magenta Dolomite

The Magenta was drilled with compressed air, and there were no indications of water inflow or accumulation from the Magenta during drilling.

3.3 Initial Results From the Culebra Dolomite

The Culebra was drilled with compressed air, and there were no indications of water inflow or accumulation from the Culebra during drilling.

On June 7, 2005, the FRP casing was placed in the hole, and the well was completed for Culebra monitoring.

After the well was completed, there was no well development.

On June 23, 2005, SNL placed a miniTroll in SNL-15 to monitor water-level changes as the well recovered after completion and to prepare for slug tests that were carried out early in 2006.

WRES began monthly water-level monitoring of the Culebra on April 11, 2006; the initial depth to water was 692.65 ft below the top of casing (US DOE, 2007).

Core photographs of Culebra Dolomite from SNL-15 representing middle (left) and lower (right) portions of the member, which has very low permeability. Vug fillings are mainly sulfate, including anhydrite and gypsum. Some halite fills fractures, such as in the left core. Cores are 4 inches across. Photographs by Dennis Powers on 6/5/2005. These photographs are not referred to in the text.

4.0 SIGNIFICANCE/DISCUSSION

The materials used in completing SNL-15 are expected to be stable over a lengthy monitoring period, in contrast to steel casing in monitoring wells drilled before 1995. Newer monitoring wells provide construction experience for groundwater surveillance wells that may be drilled in the future.

The lower Rustler and upper Salado were not penetrated at SNL-15. Previous studies of thickness changes between the Culebra and Vaca Triste Sandstone Member of the Salado (Powers, 2002a, 2003a; Powers and others, 2003) indicated that SNL-15 was located far east of the upper Salado halite margin and is the area where no halite has been dissolved. SNL-15 was also located east of the margin of halite in each non-carbonate member of the Rustler (Fig. 4-1), in areas where the halite has not been dissolved.

Halite was recovered from cores in the upper M-2/H-2 interval, as expected. The contact with the overlying Culebra showed continuous deposition and no deformation. The core from SNL-15 was consistent with the proposal by Holt and Powers (1988) that Culebra was deposited over the gray claystone and siltstone without a hiatus. The gray claystone and siltstone was deposited across (above) the halite-pan salts in the depositional center of the basin rather than being a residue after halite was dissolved from the uppermost M-2/H-2.

The most significant geologic finding of SNL-15 is the presence of halite in fractures and pore spaces of the Culebra Dolomite. Holt (1997), following the development of depositional models for the Rustler by Holt and Powers (1988), predicted that halite might form cements east of WIPP. Powers and others (2006) explored the distribution of halite in the Culebra and other Rustler units, including at SNL-15.

Culebra core recovery was complete. One reason may be the lack of porosity at SNL-15 because of halite. In addition, the drilling used compressed air, and this may also have contributed to the success in core recovery. At SNL-15, pores or vugs were less abundant than in many cores from the Culebra, and the pores are filled. Fracturing was limited, and halite filled the fractures. The Culebra overall will likely have low transmissivity.

Halite in the Tamarisk can be divided into a lower and an upper part by a sulfate bed, including polyhalite. The lower halite shows a clean lower part and an argillaceous upper part that fit with the model of mudflat to halite pan deposition established by Holt and Powers (1988).

The Forty-niner also included halite at SNL-15, showing a position within the halite pan rather than in the mudflat environment where most WIPP drillholes are located.

Cuttings and resistivity changes suggest that the sulfate cements of the Dewey Lake occur below ~250 ft bgl. This position is somewhat higher stratigraphically than at the center of the WIPP site (Powers, 2003b). The broad trend for this boundary is to be stratigraphically low west and south of the WIPP site center and stratigraphically higher in the center and eastern part of the site (Powers, 2003b). There does not appear to be a productive saturated zone at this boundary in SNL-15, or in any other part of the Dewey Lake.

The Santa Rosa is thin at SNL-15, and it was eroded before the Gatuña was deposited. Logs and cuttings indicate the Santa Rosa is interbedded sandstone and siltstones. No water was encountered in the Santa Rosa.

The Gatuña is ~20 ft thick at SNL-15. The formation tends to be thinner, or not exist, in the eastern part of WIPP. SNL-15 is located along the side of a subdued valley that trends southwest through Los Medaños to Nash Draw. It appears that the valley has developed as part of Gatuña erosion and deposition. To the north, on a topographic high, the Santa Rosa crops out and has Mescalero caliche developed on it. Gatuña may be thicker to the south in the center of the valley.

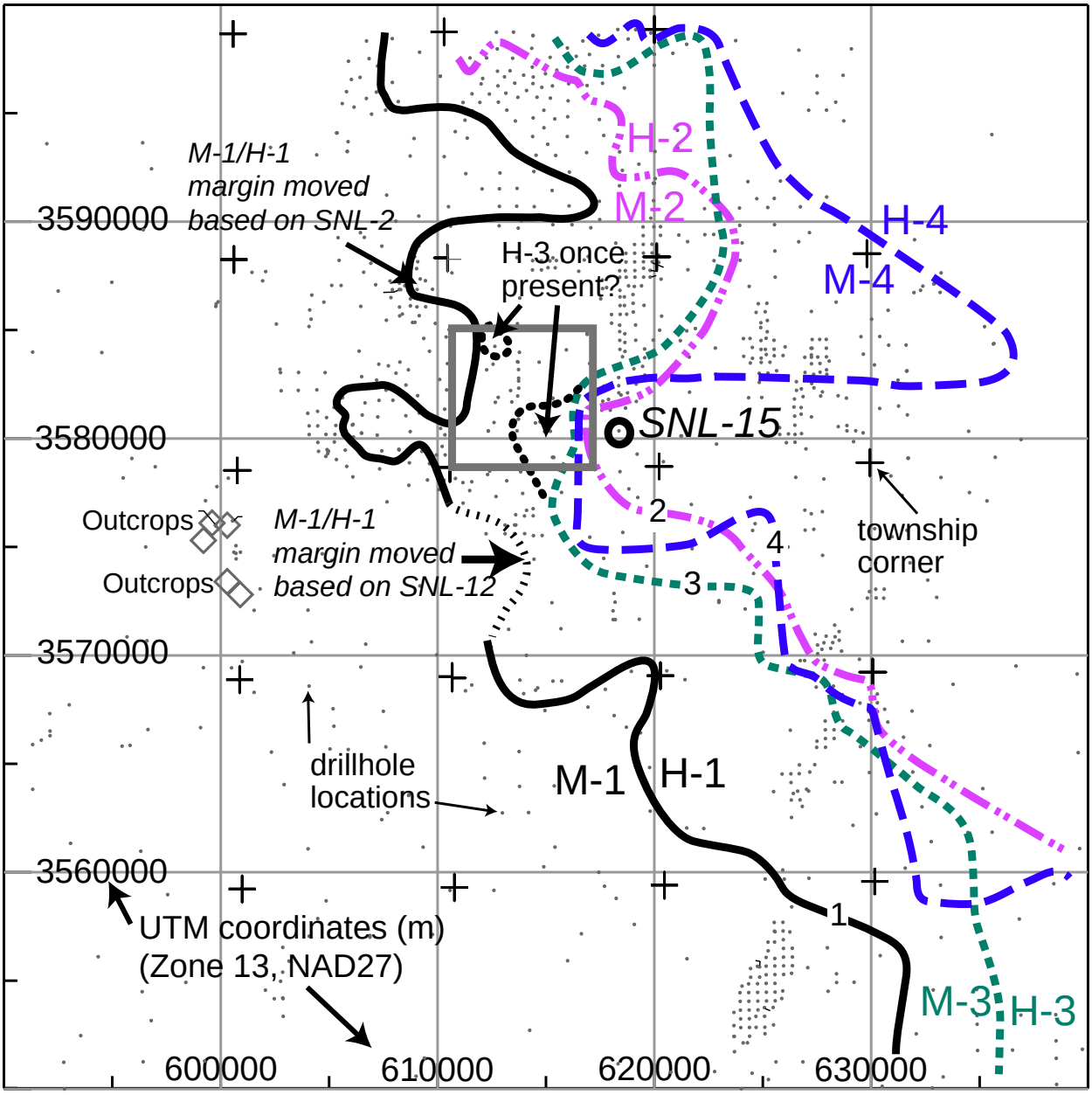


Figure 4-1. Rustler Halite Margins Near SNL-15. Halite is present east of the margins shown. SNL-15 was located in an area where Culebra transmissivity was expected to be low and halite is present in each member of the Rustler Formation. Figure modified from Holt and others (2005).

5.0 REFERENCES CITED

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

Beauheim, R.L., 1987, Interpretation of single-well hydraulic tests conducted at and near the Waste Isolation Pilot Plant (WIPP) site, 1983-1987: SAND87-0039, Sandia National Laboratories, Albuquerque, NM.

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

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

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

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

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

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

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

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

Holt, R.M., Beauheim, R.L., and Powers, D.W., 2005, Predicting fractured zones in the Culebra Dolomite, *in* Faybishenko, B, Witherspoon, P.A., and Gale, J., eds., Dynamics of Fluids and Transport in Fractured Rock: AGU Geophysical Monograph Series, v. 162, p. 103-116.

Jones, C.L., 1978, Test drilling for potash resources: Waste Isolation Pilot Plant site, Eddy County, New Mexico: U.S. Geological Survey Open-file Report 78-592, 2 v.

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

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

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

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

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

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

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

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

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

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

Powers, D.W., and Richardson, R.G., 2004, Basic Data Report for Drillhole SNL-2 (C-2948) (Waste Isolation Pilot Plant): DOE/WIPP 03-3290, U.S. Department of Energy, Carlsbad, NM.

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

Powers, D.W., Holt, R.M., Beauheim, R.L., and Richardson, R.G., 2006, Advances in Depositional Models of the Permian Rustler Formation, Southeastern New Mexico, *in* Land, L., and others, eds., Caves & Karst of Southeastern New Mexico, NMGS 57th Annual Field Conference Guidebook, p. 78-80.

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

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

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

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

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

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

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

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

U.S. Department of Energy, 2007, Waste Isolation Pilot Plant Annual Site Environmental Report for 2006: DOE/WIPP 07-2225, U.S. Department of Energy, Carlsbad, NM.

Appendix A
Drillhole Objectives

The basic document providing the basis for the drillhole and operations is the Program Plan WIPP Integrated Groundwater Hydrology Program, FY03-09 (Revision 0; Sandia National Laboratories, 2003). The main objectives are to resolve questions about water-level changes, provide data for modeling groundwater hydrology, and construct a network of wells to monitor groundwater through the WIPP operational period. Sections of this document relevant to this drillhole have been reproduced on the following pages, with the page number of the section preceding the extract and an ellipsis (…) following the end of the extracted section. A few figures have been included, but references and most figures are not included. The original document (Sandia National Laboratories, 2003) should be consulted for complete details and context for the program. Acronyms in the extracted text may not have a definition included in the extracted text.

SNL-15 was not designated as a location in the original groundwater hydrology program (Sandia National Laboratories, 2003). Within the program, the well designated WTS-3 was located where SNL-15 was drilled. WTS-3 was designated to replace plugged and abandoned well P-18, in a location east of WIPP where Culebra transmissivity is expected to be very low. This location was expected to provide confirmation of the conceptual model of Culebra hydrology. Because the program to drill most of the WTS locations was abandoned, SNL-15 was designated for this location.

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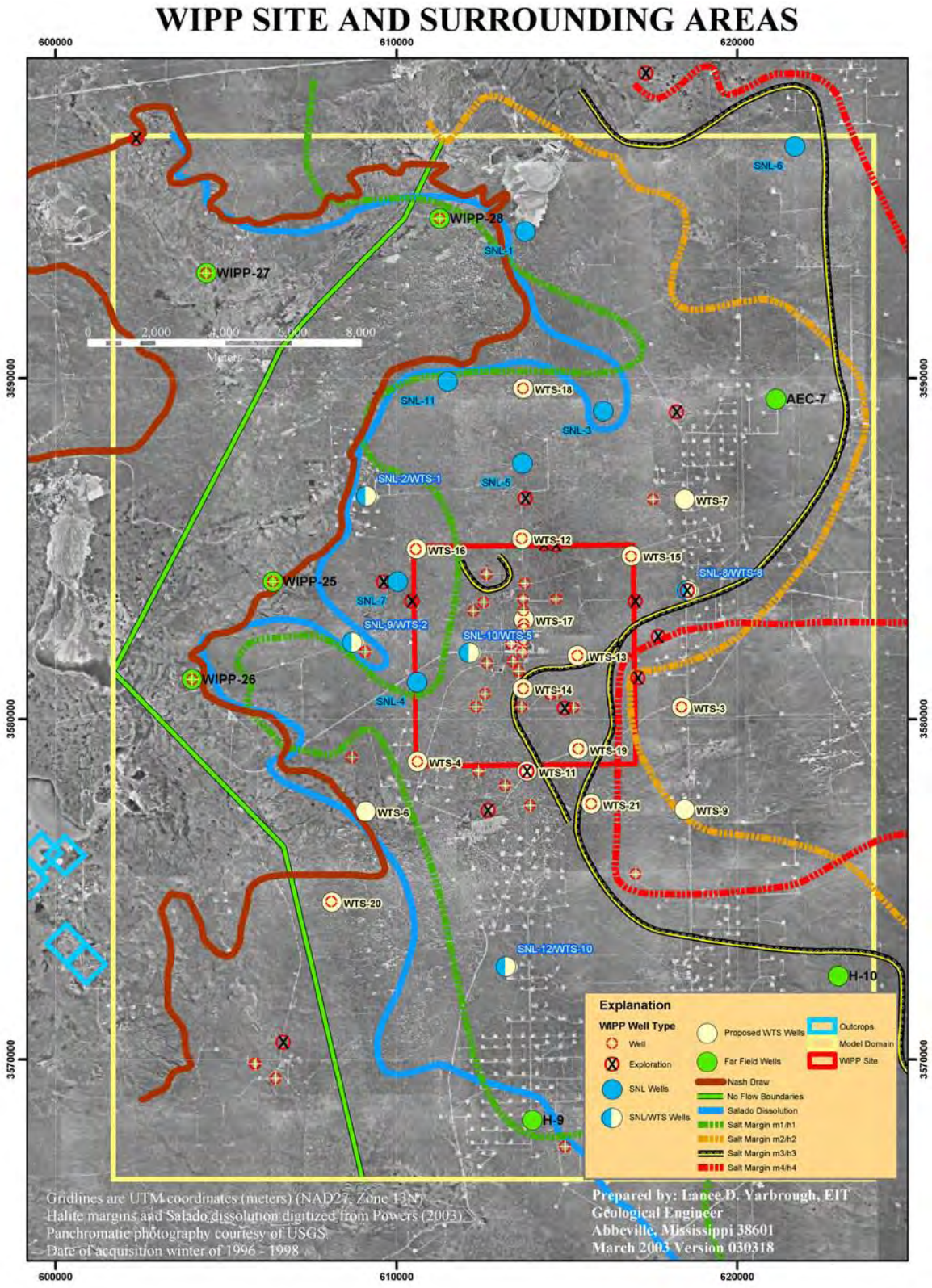
WIPP SITE AND SURROUNDING AREAS
600000
610000
620000
3590000
3580000
3570000
WIPP-28
WIPP-27
WIPP-26
WIPP-25
SNL-1
SNL-2/WTS-1
SNL-3
SNL-4
SNL-5
SNL-6
SNL-7
SNL-8/WTS-8
SNL-9/WTS-2
SNL-10/WTS-5
SNL-11
SNL-12/WTS-10
WTS-3
WTS-4
WTS-6
WTS-7
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WTS-18
WTS-19
WTS-20
WTS-21
AEC-7
H-9
H-10
0 2,000 4,000 6,000 8,000
Meters
Explanation
WIPP Well Type
Well
Exploration
SNL Wells
SNL/WTS Wells
Proposed WTS Wells
Far Field Wells
Nash Draw
No Flow Boundaries
Salado Dissolution
Salt Margin m1/h1
Salt Margin m2/h2
Salt Margin m3/h3
Salt Margin m4/h4
Outcrops
Model Domain
WIPP Site
Gridlines are UTM coordinates (meters) (NAD27, Zone 13N)
Halite margins and Salado dissolution digitized from Powers (2003)
Panchromatic photography courtesy of USGS
Date of acquisition winter of 1996 - 1998
Prepared by: Lance D. Yarbrough, EIT
Geological Engineer
Abbeville, Mississippi 38601
March 2003 Version 030318

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5. Description of Field Activities

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

5.1 New and Replacement Wells

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

5.1.1 SNL Well Justifications

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Table 1. Roles Served by Planned Wells.

Well	Addresses leakage from tailings pile	Addresses high-T conduits	Addresses leaking boreholes	Addresses Salado dissolution	Provides model boundary condition information	Provides other information needed for modeling	Provides information supporting conceptual model	Provides information on flow across WIPP site
WTS-3						X	X	

…

5.1.2 WTS Well Justifications

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WTS-3: This Culebra well will replace plugged and abandoned well P-18 east of the WIPP site, and provide needed information on transmissivity east of the m4/h4 halite margin. A Magenta well will also be installed at this location to provide information on Magenta head and transmissivity east of the site needed for modeling.

…

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Table 2. Testing to Be Performed in New/Replacement Wells.

Well	4-day Pumping Test	Slug Tests	Multipad Pumping Test	Scanning Colloidal Borescope Logging	Testing Not Needed—Replacement Well
WTS-3		C, M			

C=Culebra well
M=Magenta well

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5.3.2 Multipad Pumping Tests

Large-scale (multipad) pumping tests of the Culebra are planned for three locations to provide transient response data needed for flow-model calibration. Multipad pumping tests typically involve pumping for a month or longer at one location while monitoring responses at surrounding observation wells up to several miles away. Such tests have been performed in the past within the WIPP site boundaries at the H-3, H-11, H-19, and WIPP-13 locations, greatly facilitating model calibration in the affected areas where observation wells were present. The new wells to be installed provide the opportunity to extend the increased model-calibration capability provided by multipad tests to the regions surrounding the WIPP site, which is needed to improve our understanding of how hydraulic stresses originating off-site propagate to the wells on the WIPP site. In particular, one of the primary objectives of the multipad tests will be to determine the presence or absence of high-transmissivity connections between known areas of high T, such as between H-6 and P-14, and between H-11 and H-9. These types of features are important because, if present, they provide pathways for water from Nash Draw to flow under the Livingston Ridge surface or, if absent, they prevent that flow so that the only effect of increased heads in Nash Draw is to decrease the east-to-west gradient in the Culebra, causing heads to rise. Multipad tests will be performed north, south, and west of the WIPP site. (Transmissivity is too low east of the site to sustain the necessary pumping for a multipad test, and our conceptual model assumes the Culebra does not show the heterogeneity in this region that multipad tests are designed to address. The individual well tests at the new wells east of the site should be sufficient to confirm this assumption.)

Well SNL-9/WTS-2 will be the pumping well for the western multipad test, with observation wells as shown in Figure 18. Provided that it is able to produce at least approximately 5 gpm, SNL-5 will be the pumping well for the northern multipad test, with observation wells as shown in Figure 19. If SNL-5 does not have the needed pumping capacity, SNL-11, SNL-3, and WTS-12 (in that order) will be considered as potential fallback pumping wells for the test. The pumping well for the southern multipad test will prospectively be SNL-12/WTS-10, with observation wells as shown in Figure 20. Should SNL-12/WTS-10 not have the required pumping capacity, WTS-11 and WTS-6 (in that order) will be considered as fallback pumping locations.

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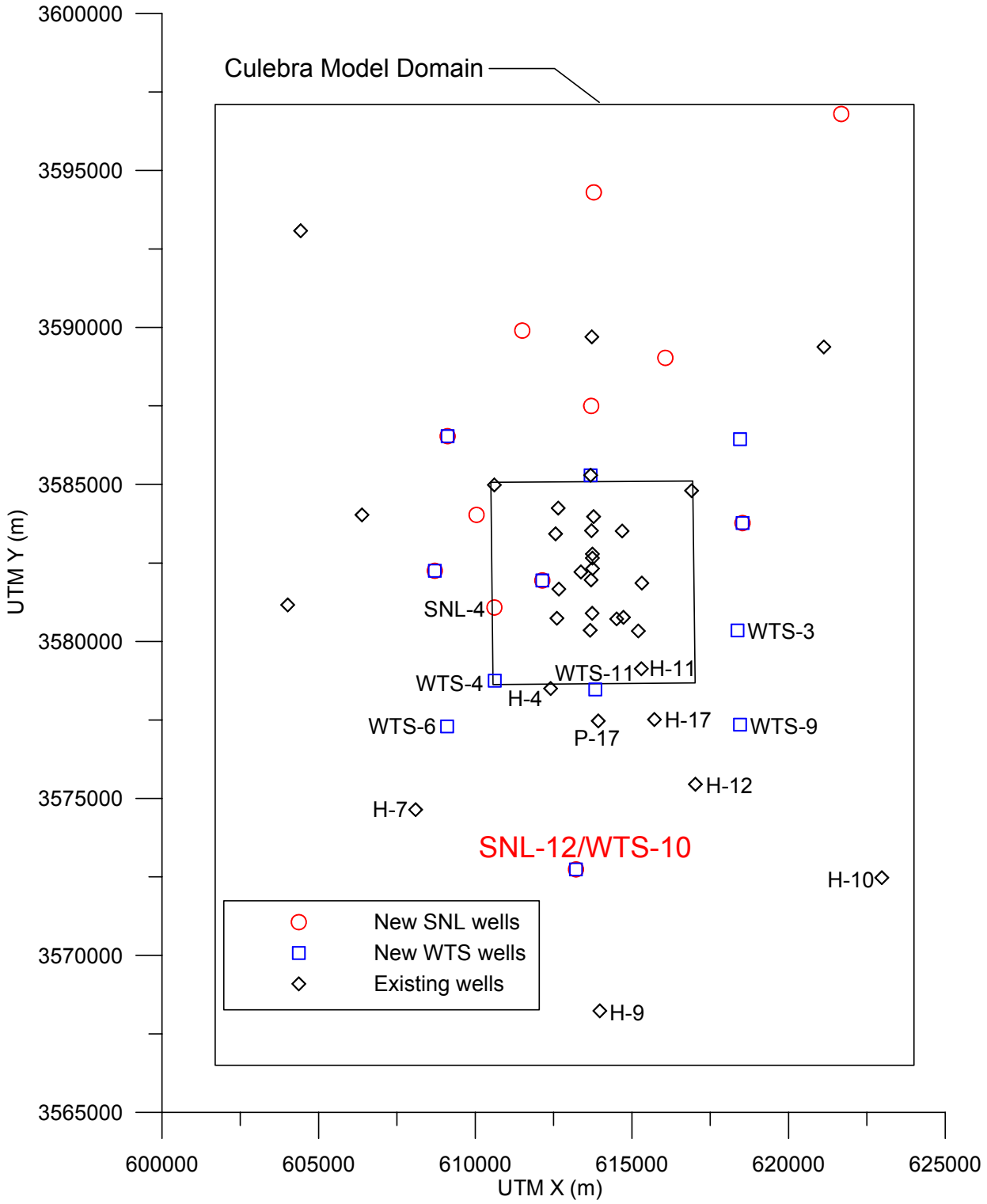

Figure 20. Pumping well and principal observation wells for southern multipad pumping test.

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Table 5. Anticipated Total Depths of Proposed Wells.

Location	Culebra Well Depth (ft)	Magenta Well Depth (ft)	Dewey Lake Well Depth (ft)
WTS-3	960	750	

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Consulting Geologist

August 1, 2004

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Ronald G. Richardson
Field Lead
Washington Regulatory and Environmental Services
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Dear Rick and Ron:

By request from Rick Beauheim, I have re-examined geologic data in the vicinity of the following potential locations for drillholes to provide recommendations on whether the locations are appropriate, considering the objectives of the drillholes.

Drillhole Name	General Location	Hydrologic Objectives	Geologic Information
SNL-6	500' fnl & fel, 7-21-32	Model boundary conditions; conceptual model: low T in area with H-2 and M-3	Better logs show H-3 present; move south ~ 1 mi
SNL-8	@ P-20; 800' fsl, 100' fel, 14-22-31	Confirm assumed low T east of WIPP, located in area of possible dissolution of halite from H-3; provide info on Culebra heads in area with many O&G wells	Logs re-examined confirm M-3 and indicate possible thicker M-3 adjacent to inferred halite margin at P-20 and adjacent O&G wells
SNL-13	SE ¼, 1-23-30	Replace WTS-4, provide monitor well in area off SW corner of WIPP where some models show flow is forced	No halite in H-2, -3, or -4; probable H-1 halite cements in most drillholes
SNL-14	SE ¼, 4-23-31	Examine area between P-17 and H-17 for possible high T zone indicated in CCA	No drillhole or other data helps define the mudstone-halite boundaries in M-2/H-2, M-3/H-3, and M-4/H-4
SNL-15	@P-10; 2300 fnl, 340' fwl, 26-22-31	Confirm T values in area with halite in all Rustler units along eastern boundary of WIPP	Drillhole data confirm halite present in P-10 and nearby oil and gas drillholes

Locations for SNL-6 and SNL-14 provide some challenges. From preliminary analysis, additional logs near the northeast corner of the hydrology domain indicate that halite is present farther west than was indicated in the original analysis (Powers, 2002). Although it is desirable to locate SNL-6 in an area without H-3, determining Culebra hydraulic properties near the boundary of the hydrologic domain is more important. SNL-6 would have to be located at considerable distance from this corner of the domain to assure not encountering H-3. Because SNL-14 is intended to test for the presence of a high T zone in the Culebra between H-17 and

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Assessing FY05 Drillhole Locations
August 1, 2004

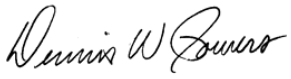
P-17, the drillhole should be located where H-3 is not present to minimize effects it may have on Culebra T values. Nevertheless, there are no drillholes between H-17 and P-17 to help delineate this margin. SNL-14 was therefore located approximately midway between the drillholes.

The coordinates for the drilling pads for each hole are:

Drillhole Name	UTM X (m) (NAD27)	UTM Y (m) (NAD27)	T,R Approximate Location (estimated)
SNL-6	621294	3595390	7-21-32, 1825 fsl, 1250 fel
SNL-8	618522	3583793	14-22-31, 900 fsl, 125 fel
SNL-13	610406	3577599	1-23-30, 1750 fsl, 400 fel
SNL-14	614871	3577302	4-23-31, 800 fsl, 1475 fel
SNL-15	617137	3581276	26-22-31, 2100 fnl, 500 fwl

Map locations, aerial photos with locations, and some site figures for each drill hole are included in the following pages.

Sincerely,



Dennis W. Powers

Note that pages of this memorandum not relevant to SNL-15 have not been reproduced.

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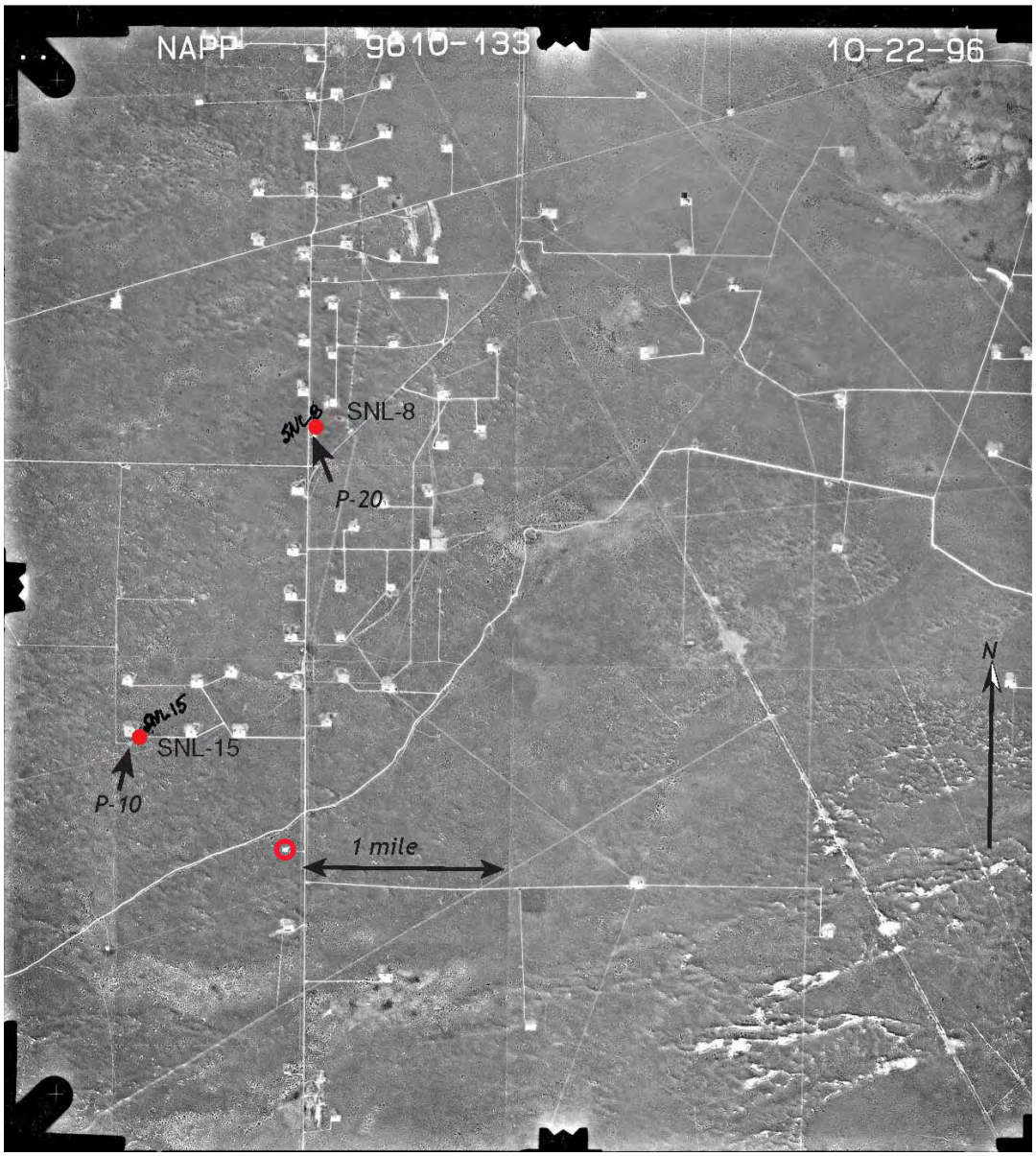
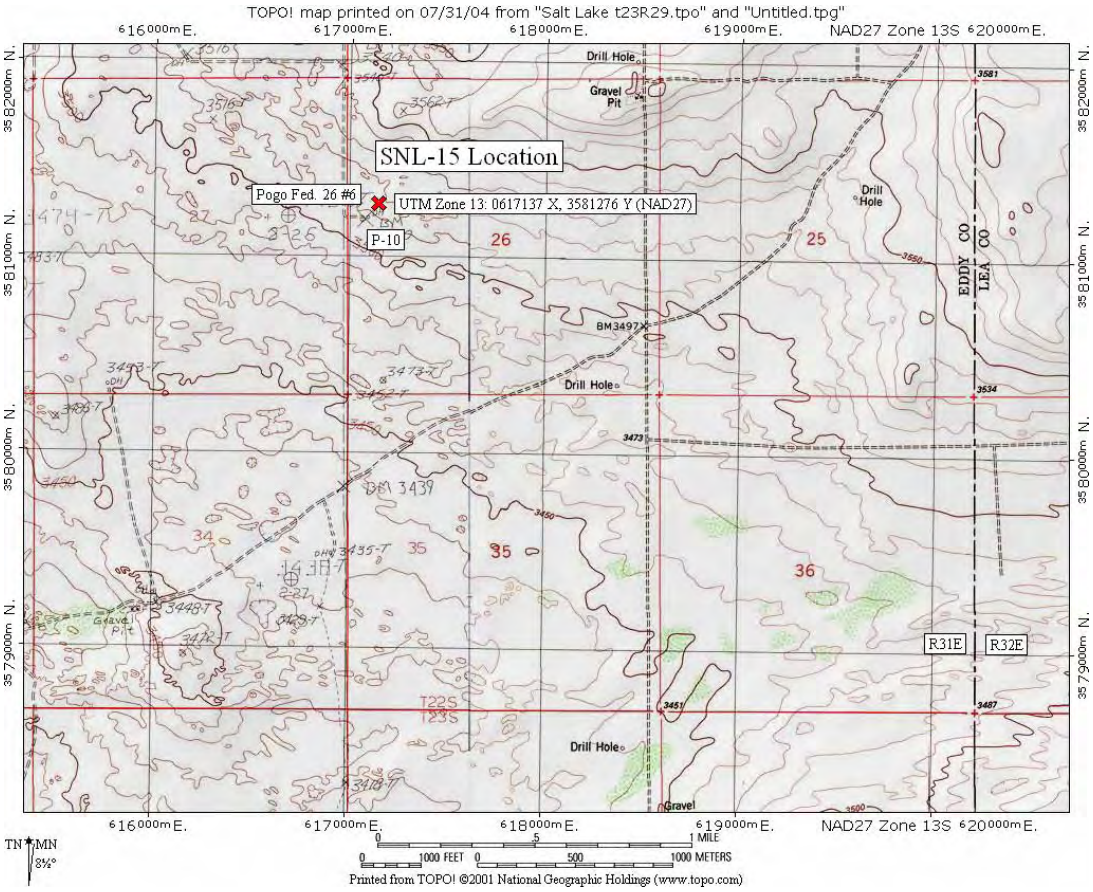


Aerial photograph showing locations of SNL-8 and SNL-15.

Note that SNL-15 was relocated to the P-18 drillpad after this memorandum; red circle has been added here to original image to show final location of SNL-15.

Dennis W. Powers, Ph. D.
Consulting Geologist

Assessing FY05 Drillhole Locations
August 1, 2004



Topographic map of SNL-15 location and photograph showing adjacent pad for oil well. WIPP Waste Handling building is on horizon just left of the pump jack.

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Consulting Geologist

March 6, 2005

Ron Richardson
Field Lead
WRES

Rick Beauheim
Hydrology Lead
Sandia National Laboratories

Drilling Estimates and Revisions for New Hydrology Wells FY2005

Because of limits to the budget for drilling in 2005, I have revised the expectations for drillholes SNL-6, SNL-8, SNL-13, SNL-14, and SNL-15 (see accompanying Excel workbook). Here I also describe the differences with respect to the hydrology plan and also initial points about these drillholes (notes adjacent to initial Excel worksheet). In reassigning coring intervals and drilling depths, I have made an attempt to maximize the information for higher priority items. That does not mean that I think the earlier objectives were unnecessary or inappropriate. At the end of the summary, I provide some additional priorities for decision-making based on incremental costs as they accrue. For easy reference, a generalized diagram of the stratigraphy of each hole and the the intervals to be cored under this revision is included at the end of the drillhole summaries.

SNL-6

Prior Expectations for SNL-6

SNL-6 was originally located in the area of the northeast corner of the hydrological modeling domain. Its purpose is to establish model boundary conditions that are important in evaluating potential vertical-leakage pathways to the Culebra. In addition, the transmissivity of the Culebra at SNL-6 was expected to be low because it is generally in the vicinity of halite in Rustler units M-2/H-2 and M-3/H-3. SNL-6 was originally scheduled to be drilled during FY04.

The hydrology plan generically indicated that wells such as SNL-6 would be cored through the Magenta Dolomite Member (~30 ft) and from the lower part of the upper Tamarisk Member anhydrite to about 20 ft below the Culebra Dolomite (~70 ft) for a total of about 100 ft.

My initial forecast called for coring from the uppermost anhydrite of the Forty-niner Member through the base of the Rustler and into the upper Salado, a total of about 350 ft. This more ambitious plan was based on the lack of control for the mudstone/halite facies in all units and unknown effects on the hydrology of the Culebra and other units. It is not believed that the upper Salado is being dissolved at this location and drilling was projected for about 50 ft below an expected top of Salado. Coring above and beyond the hydrology plan included the Forty-niner mudstone and basal anhydrite, all of the upper Tamarisk anhydrite, and all of the Los Medaños plus a short interval in the upper Salado.

Current Plan for SNL-6

The current location for SNL-6 is south of the original location, but it is in the same geological setting. Halite is anticipated in M-2/H-2, although data are sparse. The current location is not within the boundary for halite in either M-3/H-3 or M-4/H-4, but the boundary for M-3/H-3 is also not well constrained in this area.

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The revised drilling estimate is only to the depth below the Culebra necessary to establish the casing and screen interval through the Culebra. The revised core intervals include the Forty-niner mudstone and Magenta to examine the M-4/H-4 halite margin. The Tamarisk mudstone (M-3/H-3) above the Culebra is partially cored under this plan. It is expected that halite is present in this unit.

The revised plan will eliminate coring and drilling of intervals through the lower Rustler and into the upper Salado. There will be no extension of detailed facies relationships or estimation of dissolution effects, if any, from these zones.

SNL-8

Prior Expectations for SNL-8

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

The hydrology plan generically indicated that wells such as SNL-8 would be cored through the Magenta Dolomite Member (~30 ft) and from the lower part of the upper Tamarisk Member anhydrite to about 20 ft below the Culebra Dolomite (~70 ft) for a total of about 100 ft.

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

Current Plan for SNL-8

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

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

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Consulting Geologist

The revised plan will eliminate coring and drilling of intervals through and around the Magenta as well as through the lower Rustler and into the upper Salado. There will be no extension of detailed facies relationships or estimation of dissolution effects, if any, from these zones.

SNL-13

Prior Expectations for SNL-13

No drillhole designated SNL-13 was included in the original hydrological program plan. SNL-13 is located southwest of the southwest corner of the WIPP site, in an area estimated to be near the margin of halite in the lower Rustler (M-1/H-1). This location is approximately midpoint between two wells (WTS-4 and WTS-6) proposed for the groundwater monitoring program. WTS-4 was meant to replace the P&A drillhole P-15 that was monitored for a number of years. WTS-6 was to provide monitoring information as well as Culebra transmissivity data near the upper Salado dissolution margin. In addition, a Magenta well was proposed for the WTS-6 location to provided needed transmissivity and head data for modeling. WTS-4 was scheduled to be drilled in FY03; WTS-6 was scheduled to be drilled in FY04. The location of SNL-13 likely will provide information about the direction and rate of groundwater flow across the WIPP for annual reporting to the NMED.

The hydrology plan generically indicated that wells WTS-4 and WTS-6 would be cored through the Magenta Dolomite Member (~30 ft) and from the lower part of the upper Tamarisk Member anhydrite to the upper Salado (~145 ft) for a total of about 175 ft.

My initial forecast called for coring of the Magenta and from above the Tamarisk mudstone into the upper Salado, a total of up to 320 ft. This plan was based on the lack of detail for the mudstone/halite facies in all units in this area, although the halite facies limits for each unit has already been estimated based on the descriptions from nearby drillholes. It is not known whether the upper Salado is being dissolved at this location and drilling was projected as much as 235 ft below an expected top of Salado to reach a marker bed. Coring above and beyond the hydrology plan included more of the lower Tamarisk and a longer interval in the upper Salado.

Current Plan for SNL-13

The location for SNL-13 has not changed significantly since it was first proposed. Halite not anticipated in M-2/H-2 or higher. The halite margin for M-1/H-1 is not well constrained in this area. Geophysical logs from surrounding drillholes have been briefly examined and are expected to yield enough information to supplement data from drilling and coring the Rustler/Salado contact.

The revised drilling estimate is to a depth about 10 ft below the Rustler/Salado contact to try to establish whether halite has been dissolved from the uppermost Salado. The core and drilling will also investigate the presence of halite in the upper part of M-1/H-1 and obtain some textural details. The Tamarisk mudstone (M-3/H-3) through Culebra is cored under this plan. The revised

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core interval includes coring of the Magenta; Magenta hydraulic properties in this area are likely to be important, and the hydrology plan locates a Magenta well in this area (WTS-6).

SNL-14

Prior Expectations for SNL-14

No drillhole designated SNL-14 was included in the original hydrological program plan. SNL-14 is located south of the southern boundary of the WIPP site, about midway between drillholes P-17 and H-17, where the Culebra has been tested and monitored. SNL-14 is about centered in an area that was designated the "high-T zone" for the Culebra in many earlier reports. The nearest equivalent well in the existing hydrology program plan was designated WTS-11, and it was originally located nearer the southern WIPP boundary, at the drillpad for P-8. WTS-11 was intended to be a replacement for P-17. WTS-11 was to provide monitoring information as well as Culebra transmissivity data. WTS-11 was scheduled to be drilled in FY05. The location of SNL-14 likely will provide information about the direction and rate of groundwater flow across the WIPP for annual reporting to the NMED.

The hydrology plan generically indicated that wells such as WTS-11 would be cored through the Magenta Dolomite Member (~30 ft) and from the lower part of the upper Tamarisk Member anhydrite to below the Culebra (~70 ft) for a total of about 100 ft.

My initial forecast called for coring the Forty-niner mudstone and through the Magenta and from above the Tamarisk mudstone into the upper Salado, a total of up to 350 ft. This plan was based on the lack of detail for the mudstone/halite facies in all units in this area and the import of SNL-14 as an indicator of the "high-T zone" that is not as prominent in recent modeling based on the Culebra geohydrological conceptual model. Nearby drillholes (P-17 and H-17) bracket the presence and absence of halite in the units above and below the Culebra, and this location is important as a test of the extension of a possible dissolution zone in M-3/H-3. The upper Salado is not likely to be dissolved at this location, but drilling and coring was projected into the upper Salado to thoroughly test the any relationship between high Culebra transmissivity and upper Salado dissolution. Coring above and beyond the hydrology plan included more of the lower Tamarisk and a longer interval in the upper Salado.

Current Plan for SNL-14

Since it was first proposed, the location for SNL-14 has been moved somewhat to mitigate impacts from construction near the Los Medaños, but it is still located along a general midline between H-17 and P-17. There are no changes in the estimates of the geological setting for this drillhole from the original plan for SNL-14. Although SNL-14 is south of the intended location for WTS-11, the geology is expected to be similar.

The revised drilling estimate is to a depth about 50 ft below the Culebra, the depth necessary to check reasonably for halite in the underlying M-2/H-2 and M-1/H-1. The revised core interval includes the Magenta, although there is no plan to locate a Magenta well in this area. The interval including Tamarisk mudstone (M-3/H-3) through Culebra and into the middle of the Los

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Medaños is cored under this plan. This provides a test of the halite in the Tamarisk mudstone as well as an attempt to intercept the upper halite of the lower Rustler (M-1/H-1).

This revised plan eliminates coring of the Forty-niner mudstone to examine the M-4/H-4 halite margin, and it eliminates coring and drilling of the lowermost Rustler and Salado. Direct drillhole and textural evidence from these zones will not be obtained.

SNL-15

Prior Expectations for SNL-15

No drillhole designated SNL-15 was included in the original hydrological program plan. SNL-15 is now located east of the eastern boundary of the WIPP site at the drilling pad for P-18, where the Culebra has been tested and monitored. The hydrology program plan included a groundwater monitoring well (WTS-3) at this location for the Culebra as well as a Magenta test well. Culebra transmissivity is very low at P-18 compared to other test holes, and the presence of halite in underlying and overlying units is believed to be related to the low transmissivity. Because M-4/H-4 above the Magenta is also expected to have halite, the Magenta characteristics here are also of interest. WTS-3 was scheduled to have both Culebra and Magenta wells drilled and completed in FY05. Another groundwater monitoring well (WTS-9) in this same geological setting, but nearer halite margins, was also scheduled to be completed in FY05.

The hydrology plan generically indicated that wells such as WTS-3 and WTS-9 would be cored through the Magenta Dolomite Member (~30 ft) and from the lower part of the upper Tamarisk Member anhydrite to below the Culebra (~70 ft) for a total of about 100 ft.

My initial forecast for SNl-15 called for coring the entire Rustler Formation to establish all of the facies relationships toward the depositional center where all mudstone/halite units are believed to include halite. Including a short interval from the upper Salado brought the estimated core interval to 475 ft. Coring above and beyond the hydrology plan included the upper contact of the Rustler with Dewey Lake, all of the Forty-niner, all of the Tamarisk and all of the Los Medaños.

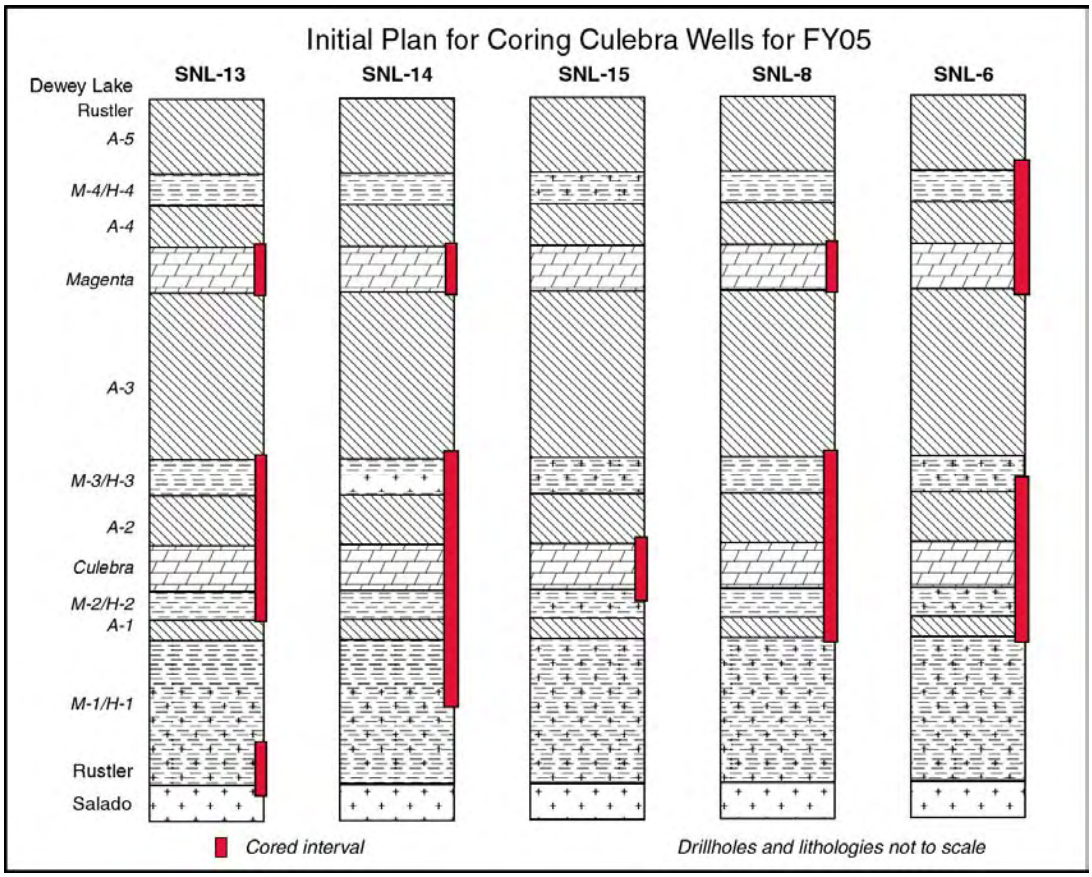
Current Plan for SNL-15

The location for SNL-15 has been moved somewhat since it was first located nearer the halite margins. Proposed locations near existing oil wells were not acceptable to the companies involved. The P-18 drillpad does not have this problem, and it is clearly in a region of hydrological interest. The potential effects of being near a halite margin are not going to be tested in this drillhole, but it should provide more of a benchmark regarding low transmissive Culebra and the relationship of transmissivity of Rustler units to halite in the formation.

The revised drilling estimate is to a depth about 23 ft below the Culebra to allow completion. The revised core interval includes the Culebra and the upper Los Medaños (M-2/H-2).

This revised plan eliminates coring of all Rustler except the Culebra and immediate surrounding units. The evidence regarding halite from P-18 above the total depth of SNL-15 is expected to be confirmed by cuttings. Although a well for the Magenta was proposed here in the hydrology

plan, the Magenta has not been included in coring here because of immediate costs. It could also be cored if a Magenta well is actually sited here.



Priorities for Making Decisions During Drilling

Expansion of Drilling and Coring
If the accrued expenses of drilling permits additional targets to be designated, here are my priorities, from higher to lower:

- M-4/H-4 at SNL-8 (+ 35 ft)
- Magenta Dolomite at SNL-15 (+ 30 ft)
- Extend coring above and below Culebra (+ 40 ft)

Contraction of Drilling and Coring
If accrued expenses of drilling require coring to be reduced in later drillholes, here are my priorities, from first to be reduced to last to be reduced:

- Eliminate Magenta at SNL-8 (- 30 ft)
- Eliminate Forty-niner coring at SNL-6 (- 40 ft)
- Eliminate Magenta coring at SNL-6 (- 30 ft)

Dennis W. Powers, Ph. D.
Consulting Geologist

Drilling Estimates and Revisions FY2005
March 6, 2005

Summary Comments on Revisions

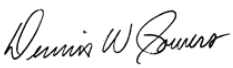
The initial program of drilling and coring I recommended was aggressive, and I intended it to provide a solid base of physical evidence bearing on the geohydrological factors that contribute to the understanding of the spatial variation in the hydraulic properties of the Culebra Dolomite as well as the Magenta Dolomite. A hydrogeological conceptual model of the Culebra has been put forward, and these drillholes provide additional means of testing that model. Although a similar conceptual model of the Magenta has not yet been established, the spacing and distribution of these drillholes potentially add much to the existing coverage, as the eastern sector of the WIPP hydrologic modeling domain is not well represented by cores. Although Salado dissolution is not expected to be a significant factor in any of these five locations except possibly SNL-13, the distribution of halite and other Rustler facies, along with depth, are expected to be significant for the Culebra. The general distribution of halite in the Rustler is believed to be well known, but the margins are still poorly sampled to determine the potential for dissolution to have affected local halite distribution and hydraulic properties of these units.

With budget limitations in mind, I have attempted my version of *triage* – to sort or allocate on the basis of need for or likely benefit from ….

I have eliminated all drilling and coring of the basal Rustler and upper Salado except for SNL-13, which is located in part to test the potential effects of upper Salado dissolution. Data from other drillholes will supplement the estimate of upper Salado dissolution at SNL-13 and the amount of coring and depth has been greatly reduced. Drilling of the basal Rustler and upper Salado in the remaining holes, without core, would not significantly improve knowledge, although a specific data point on the contact might be provided by a geophysical log. I have eliminated coring of any units significantly above or below the Culebra in SNL-15 because there is little doubt about the presence of halite in all mudstone/halite units. I have also eliminated coring of some mudstone/halite units in different holes to focus on the greatest priority, the Culebra Dolomite.

Thirty years of experience at WIPP indicate to me that the cost of not having information and the cost of later providing equivalent information is more expensive than the savings of the moment. Nevertheless, I provide here a basis for choosing drillhole depths and core intervals from the five wells to be drilled and completed in FY04 with these limitations in mind. I will work with you on priorities as the drilling unfolds to do my best to balance the technical needs and budgetary limitations.

Sincerely,



Dennis W. Powers

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 Service (WRES) personnel, and geologic logs by Dennis W. Powers. The main information is from WTWWS reports, which are reported as Central Daylight Time. For consistency, all information in the abridged borehole history has been converted to Central Daylight Time, regardless of source. Original files are maintained by WRES in the Environmental Monitoring and Hydrology Section.

Note: The abridged drillhole history provided here has been compiled mainly from the daily records produced by personnel of West Texas Water Well Service (WTWWS) and provided to Ron Richardson (Washington Regulatory and Environmental Services). The information has been reformatted and has been modestly edited. *Additions to the record from notes by Dennis Powers or other personnel are in italics.* All times reported in the abridged drillhole history are in CDT (Central Daylight Time) as recorded by WTWWS because they operate from Odessa, TX. Any additional notes included here (*in italics*) with times recorded in MDT (Mountain Daylight Time) at the site have been converted to CDT. Geologic logs (main body of text) have times as MDT, and times in the geologic logs commonly vary slightly from driller's log after allowing for the hour time difference. Drilling operations at SNL-15 were under restrictions because the site is located in designated prairie chicken habitat. As a consequence, actual rig operations could not begin until after 09:00 MDT or 10:00 CDT each day.

6-01-05 Left Odessa, TX, at 08:00 CDT (*see note above*) and arrived at SNL-15 drillpad site at 09:30. Conducted safety meeting. Set rolloff from Tripod. Drilled 12.75" hole to 39.5' by 11:00. Tripped out of hole by 11:12. Prepared to run surface casing by 11:25. Pulled surface casing from hole and reamed to 39.5' from 11:25 to 12:20. Reran 40' casing in hole, leaving 6" stickup above pad level. Cemented surface casing with 42 sacks of cement, *formed pad,* and left site at 14:30.

6-02-05 Arrived on site at 10:00. Held safety meeting. Rigged up diverter for drilling with air and completed rigging up at 13:20. Drilled 7.875" hole from 39.5' at 13:20. Reached 330' at 19:58. Tripped out to collars by 20:15 and departed site.

6-03-05 Arrived on site at 10:05. Held safety meeting. Tripped into hole by 10:40. *No water in drillhole.* Worked on mist pump until 11:15. Drilled 7.875" hole from 330' beginning 11:25. Reached 650' at 19:25. Tipped out of hole to collars, shut down, and departed site *at 20:15*.

6-04-05 Arrived on site at 10:15. Held safety meeting. Tripped into hole from 10:30 to 11:06 to 650'. Drilled from 650' to 900' by 17:46, reaching coring point. Tripped out drillhole by 18:35, shut down and departed site.

6-05-05 *Richardson on site at 09:00, performed housekeeping chores. John Wood (Diamond Oil Well Drilling Company - DOWDCO) arrived at 09:35.* WTWWS crew arrived on site at 10:00. Held safety meeting and performed rig maintenance. *Action Safety personnel on site 10:15 for inspection.* Put core tool together and began to trip in at 11:02. Reached bottom (900') and began to core at 12:20. Cut 27' by 13:35. Tripped out by 15:14. Laid down core, recovering 27'. Tripped into hole from 15:40 to 16:55. Cut 23' (950') by 17:30. Tripped out by 18:20 and laid down core; 24' recovered. Broke down core tool and loaded it for DOWDCO. *John Wood departs site at 19:20. Shut down and left site at 20:00.*

6-06-05 Arrived on site at 10:00. Held safety meeting. Laid rig over to install new cat rope. *Lea Land on site,* moved rolloff out by 10:47. Placed 4.5 bags of HolePlug® to plug cored section from 950' to 938'. Tripped into hole with 7.875" bit and reamed cored section to 940'

from 12:20 to 13:40. Tripped out of hole by 14:40. Removed diverter from rig by 15:05. Jet West (Al Henderson) on site and logged well from 15:05 to 17:45. Secured site and left.

6-07-05 Arrived on site at 10:00. Held safety meeting. Loaded drill pipe onto truck. Laid out tremmie pipe and tallied lengths. Ran tremmie pipe into hole by 12:45. *Mike Stapleton (New Mexico State Engineer representative) on site at 14:20 to observe completion.* Ran 2.5-inch fiberglass-reinforced plastic casing into hole to 935' by 15:12. Screen interval is from 928.5-902' below ground level, with 0.070-inch slots. Put 1 bag of HolePlug® into the annulus below pipe. Placed 4/10 gravel from 935' to 896' by 16:09. Put 3 additional bags of HolePlug® on gravel to bring seal to 891' by 14:30 and allowed plug to set for 15 minutes. *LaFarge on-site at 16:20; set up and* pumped cement from 16:45 to 17:50. *Stapleton departs 17:00.* Pulled tremmie pipe from hole by 18:20. Shut down and departed site.

Luis Armendariz (l) of West Texas Water Well Service and John Wood (r) of Diamond Oil Well Drilling Company prepare to core SNL-15 on June 5, 2005.

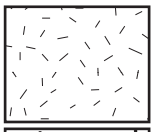
Appendix C
Geologic Logs

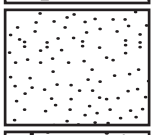
Note: The original field descriptions and graphic logs were prepared at differing scales, and the graphic logs for publication were generally produced at 10 or 20 vertical ft per inch, as indicated in the header for the log.

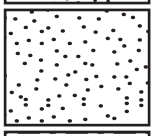
The field descriptions were related to depth based on drilling information and core recovery as best determined in the field. Core and sample footages are marked accordingly and can vary somewhat from depths determined for stratigraphic units based on geophysical logs (see Table 2-1 of text). Core depth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

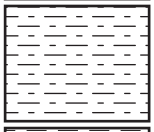
Explanation of Symbols Used in Lithologic Logs (Appendix C)

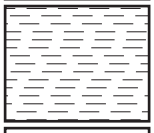
Lithology

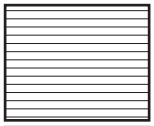

Construction fill

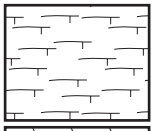

Fine sand or sandstone

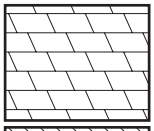

Medium or coarse sand or sandstone

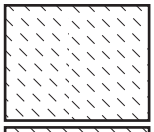

Siltstone

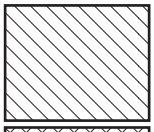

Claystone

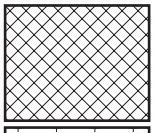

Organic-rich, claystone

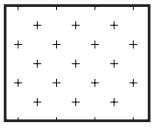

Carbonate (pedogenic calcrete)


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 7

Hole ID: SNL-15
Location: SE 1/4 of SE 1/4, section 26, T23S, R31E, Eddy Co, NM

Drill Date: 6/1/2005
Drill Crew: West Texas Water Well Service
Drill Method: Rotary with air
Hole Diameter: initial 7.875 inches
Hole Depth:
Hole Orient: vertical downward
Drill Make/Model: Gardner-Denver 1500
Barrel Specs: 6.75 in o.d., 4 in. core
Drill Fluid: air
Core Preserv: box as is

Logged by: Dennis W. Powers, Ph.D., consulting geologist
Date: 6/1-2/2005
Scale: 1" = 20 ft

UTM (NAD27)	Northing	Easting	Elevation (amsl)
Survey Coordinate: (m)	3580336.30 m	618352.94 m	3477.94 ft

Comments: Described lithology from ground level to 900 ft on the basis of collected cuttings. Cored interval described on p.7. Cuttings were generally collected at 10 ft intervals

Run Number	Depth (ft)	% Recovered	RQD	Profile (Rock Type)	Description Contacts are placed midway between samples	Remarks
N/A	0	N/A	N/A		0-5': Dune sand; weak red (2.5YR4/2); f-vf, subround to round grains; <1% dark opaque grains; friable	Drilled to 39.5 ft; set 40 ft of steel casing with o.d. of 8.625 inches and cemented to surface
		C-1			10': Calcareous sandstone (Mescalero caliche), white; f-vf, subround grains; few dark opaque grains; moderate induration; with calcareous sandstone (Gatuña Formation); red (2.5YR5/6); vf-f, subround; few dark opaque grains; some MnO_2 stains; moderate to strong induration.	
		C-2			20': Gatuña as above.	
	20	C-3			30': Calcareous sandstone (Gatuña); pink (5YR7/3); med-vf; subround to rounded grains; ~1% dark opaque grains; MnO_2 stains; strong induration.	
		C-4			40': Siltstone, argillaceous (Santa Rosa Formation); yellowish red (5YR6/6); with some probably mica; non-calcareous; moderate induration	Begin drilling from 39.5 ft with air on 6/2/05.
	40	C-5			50': generally as above; reddish-brown (5YR5/6); slightly more indurated	
		C-6			60': as above	
	60	C-7			70': Sandstone, silty; light reddish-brown (5YR6/4); v.f-f; well indurated; fine laminae (0.125 inch); few mica grains	
		C-8			80': as above, more mica and coarser grains: med to vf.	
	80	C-9			90': Siltstone, argillaceous; reddish-brown (5YR4/4); moderate induration, some possible mica; slightly calcareous; upper Dewey Lake Formation	
		C-10			100': Siltstone, argillaceous; reddish-brown (2.5YR4/4); moderate induration	
	100	C-11				

Hole ID: SNL-15 CORE LOG (cont. sheet) Sheet 2 of 7

Logged by: Dennis W. Powers, Ph.D. Date: 6/2/05

Run Number	Depth (ft)	% Recovered	RQD	Profile (Rock Type)	Description	Remarks
N/A	100	N/A	N/A			
		C-12			110': Siltstone, argillaceous and sandy; reddish-brown (2.5YR4/4); moderate induration	
	120	C-13			120': similar to above, with some hard sandstone chips of similar color; f-vf sand grains; well indurated	
		C-14			130': similar to 110'.	
	140	C-15			140': Siltstone, argillaceous; reddish brown (2.5YR4/4); moderate induration	
		C-16			150': similar to above	
	160	C-17			160': similar to 120'.	
		C-18			170': similar to 120', more sand than at 160'.	
	180	C-19			180': similar to 110'	
		C-20			190': similar to 110'	
	200	C-21			200': similar to 170'	
		C-22			210': similar to 110', trace of fibrous gypsum	
	220	C-23			220': similar to 210'	
		C-24			230': simlar to 110', no trace of gypsum	
	240	C-25			240': similar to 120', mixed sandstone and siltstone	
		C-26			250': Siltstone, reddish-brown (2.5YR5/4); poorly indurated, trace gypsum	
		C-27			260': Sandstone, weak red (2.5YR5/2); vf; well indurated, may be cemented with sulfate; platy	
	260					

Hole ID: SNL-15 CORE LOG (cont. sheet) Sheet 3 of 7

Logged by: Dennis W. Powers, Ph.D. Date: 6/2-3/05

Run Number	Depth (ft)	% Recovered	RQD	Profile (Rock Type)	Description	Remarks
N/A	260	N/A	N/A			
		C-28			270': similar to 260'; fibrous gypsum common	
	280	C-29			280': similar to above, little gypsum	
		C-30			290': similar to above, more gypsum.	
	300	C-31			300': similar to above, less gypsum	
		C-32			310': similar to above, more gypsum	
	320	C-33			320': similar to above; little gypsum	
		C-34			330': similar to above, slightly more red (2.5YR5/4; reddish brown); small (<0.05 inch) greenish reduction spots becoming more common	End drilling @ 330' 6/2/05; begin drilling @ 330' 6/3/05; air
	340	C-35			340': similar to 320'; small greenish reduction spots common	
		C-36			350': as above	
	360	C-37			360': as above	
		C-38			370': as above	
	380	C-39			380': Siltstone, little sand; reddish brown (2.5YR5/4); common plates of fibrous gypsum	
		C-40			390': similar to 370'	
	400	C-41			400': as above	
		C-42			410': as above	
		C-43			420': as above	
	420					

Hole ID: SNL-15 CORE LOG (cont. sheet) Sheet 4 of 7

Logged by: Dennis W. Powers, Ph.D. Date: 6/3/05

Run Number	Depth (ft)	% Recovered	RQD	Profile (Rock Type)	Description	Remarks
	420					
N/A		N/A	N/A			
		C-44			430': Siltstone, sandy; reddish brown (2.5YR5/4); vf sand; small greenish-gray reduction spots (generally < 0.25 inch) common; well indurated; fibrous gypsum common	
	440	C-45			440': similar to above, little gypsum	
		C-46			450': similar to above	
	460	C-47			460': similar to above, more gypsum	
		C-48			470': similar to above, little or no gypsum	
	480	C-49			480': similar to above	
		C-50			490': similar to above, some gypsum	
	500	C-51			500': similar to above, little or no gypsum	
		C-52			510': similar to above, some gypsum	
	520	C-53			520': similar to above; reduction spots generally larger	
		C-54			530': Siltstone; reddish brown (2.5YR5/4); some reduction spots, little or no gypsum; moderate induration	
	540	C-55			540': similar to above	
		C-56			550': Siltstone, sandy; similar to 500'; little gypsum	
	560	C-57			560': Siltstone, similar to 530'	
		C-58			570': similar to above; trace gypsum	
		C-59			580': Siltstone, sandy; similar to 530'	
	580					

Hole ID: SNL-15 CORE LOG (cont. sheet) Sheet 5 of 7

Logged by: Dennis W. Powers, Ph.D. Date: 6/3-4/05

Run Number	Depth (ft)	% Recovered	RQD	Profile (Rock Type)	Description	Remarks
N/A	580	N/A	N/A			
		C-60			590': Siltstone, sandy; reddish brown (2.5YR5/4); vf sand; small greenish-gray reduction spots (generally < 0.25 inch); moderate induration; trace fibrous gypsum	
	600	C-61			600': Siltstone, slightly sandy; reddish brown (2.5YR5/6); few reduction spots; little gypsum	
		C-62			610': similar to 590'	
	620	C-63			620': similar to 590'	
					approximate base Dewey Lake Formation	
		C-64			approximate top Rustler Formation	
		C-65			627': Anhydrite, white to light gray, fine crystalline 630': similar to above, little or no gypsum	
	640	ns				
		C-66			650': similar to above	End drilling @ 650' on 6/3/05 Begin drilling @ 650' on 6/4/05
	660	C-67			660': Halite, clear; with some mixed anhydrite as above	
		C-68			670': Siltstone, sandy; weak red (2.5YR5/2)	
	680	C-69			680': Halite and weak red siltstone, mixed	
		C-70			690': Siltstone; gray (2.5YRN/6); minor clear halite	
	700	C-71			700': similar to above; no halite	
		C-72			710': Dolomite, weak red (2.5YR5/2)	
	720	C-73			720': similar to above	
		C-74			730': Anhydrite, gray	
		C-75			740': similar to above	
	740					

approximate Forty-niner Member extent

~Magenta Dolomite Member

~Tamarisk Member

Hole ID: SNL-15 CORE LOG (cont. sheet) Sheet 6 of 7

Logged by: Dennis W. Powers, Ph.D. Date: 6/4/05

Run Number	Depth (ft)	% Recovered	RQD	Profile (Rock Type)	Description	Remarks
N/A	740	N/A	N/A			
		C-76			750': Anhydrite, gray, fine to medium crystalline	
	760	C-77			760': similar to above	
		C-78			770': similar to above	
	780	C-79			780': similar to above	
		C-80			790': Anhydrite, white to light gray, fine crystalline	
	800	ns				
		ns				
	820	ns				
		C-81			830': Anhydrite, gray (may be from above)	
	840	C-82			840': Siltstone, reddish brown (2.5YR5/4); with clear halite	
		C-83			850': similar to above	
	860	ns				
		C-84			870': similar to above	
	880	C-85			880': similar to above; with gray siltstone	
		C-86			890': Anhydrite, gray	
		C-87			900': similar to above	End drilling @ 900' on 6/4/05
	900					

approximate Tamarisk Member extent

Hole ID: SNL-15 CORE LOG (cont. sheet) Sheet 7 of 7

Logged by: Dennis W. Powers, Ph.D. Date: 6/5/05

Run Number	Depth (ft)	% Recovered	RQD	Profile (Rock Type)	Description	Remarks
1	900	cut 27'; recovered 27.4'	~8' in segments <4"; RQD = 70.8		Ahydrite and gypsum, dark gray, generally f-m crystalline, with clear gypsum in pores and sulfate needles grown into space before gypsum crystallized. Thin beds to laminae; purplish from 904.2-904.6'	Begin coring @ 900' on 6/5/05
					904.9' Base of Tamarisk Member Top of Culebra Dolomite Member	
	910				Dolomite, light gray (5Y7/2) to pale yellow (5Y8/3); bedded, some wavy thin laminae; large (to ~2") anhydrite and gypsum nodules scattered throughout. Tiny (<1/16") vugs filled with silt (dolomite?) from ~934', become slightly larger from ~925.5'; filling is darker in some vugs, brown from 925.6-922.5'; not present above 919'. Sub-vertical, irregular to somewhat planar, fractures with halite fill (apertures ~0.01-0.03 inches) at 1-3 inch horizontal spacing; some bedding plane halite. Wavy laminae 910.1-910.5', 910.8-912.3'. Sandy dolomite 921.2-921.3'. Erosion surface(?) at ~923' above laminar zone	
	920					
2	930	cut 23'; recovered 24.1'	~8.5' in segments <4"; RQD = 64.7		935.4' Base of Culebra Dolomite Member Top of Los Medaños Member	
					935.4-938.7': Claystone, silty, gray (5Y5/1) at base to dark gray (5Y4/1) at top; gypsum 938.3' and 936'. Thin bedded and thin laminae, ~horizontal. Gypsum and halite(?) in narrow fractures 936.5-937'; slickensides to ~50° from horizontal. 938.7-951.5': Halite, clear, gray to slightly orange, f-vc (up to 1.5"), with variable amounts of silty claystone (5YR5/4; reddish-brown) in interstices and as irregular beds and zones; halite is displacive in mud, with mainly more irregular boundaries and some incorporative growth. Sulfatic 943.3-945.5', polyhalite(?) 943.3-943.7'.	
	940					
	950					End coring @ 951.5' on 6/5/05
	960					
	970					
	980					

Storm clouds southeast of SNL-15 as seen from SNL-15 well pad June 5, 2005.
Photo by Denis W. Powers.

Appendix D
Permitting and Completion Information

A case file for SNL-14 (C-3152) 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-3152.

Information on management of well-drilling wastes for SNL-15 is not included; at the time of basic data report preparation, these wastes were still being characterized for disposal.

Dennis W. Powers, Ph. D.
Consulting Geologist

June 6, 2005

Ron Richardson
Field Lead
WRES

Rick Beauheim
Hydrology Lead
Sandia National Laboratories

Re: Screen Interval for Culebra Dolomite Member in SNL-15

The information regarding the Culebra Dolomite Member in SNL-15 indicates that the best interval to screen is from 902–928.5 ft below the drilling pad level. This decision is based on geophysical logs completed on June 6, 2005 (see attached figure) and cores from SNL-15.

These are factors considered in this decision for SNL-15:

- The Culebra interval, based on the natural gamma geophysical log, is from 902–932 ft. This interval is 30 ft thick, a little thicker than average around the WIPP site, and it is consistent with the recovered core thickness. There is little indication of fluid production from the Culebra; fractures and some pore spaces are filled with halite.
- The transition from Culebra to Los Medaños was recovered, showing the gray claystone below the Culebra was indurated and not particularly plastic. The base of the screen will be placed at ~928.5 ft to provide best coverage of Culebra, well above the claystone.
- The screened or slotted section of the casing joint is expected to be ~26.5 ft long. This will incorporate all of the Culebra except the basal 3.5 ft, which has little porosity.
- Halite was detected about 3 ft below the Culebra in M-2/H-2. HolePlug® will be placed around the blank below the Culebra, to ~935 ft, helping to isolate this interval. HolePlug® was also put into the drillhole to plug from 940 ft to total depth before reaming the cored interval to a final nominal diameter of 7.875 inches to a depth of 940 ft. There is little potential for dissolution of this salt by Culebra brine.
- Geophysical logs and core indicate the anhydrite (A-2) above the Culebra is intact. There is halite in this unit and H-3 is present above A-2. HolePlug® above the gravel pack will restrict fluid movement. There is little potential for dissolution by any Culebra brine.
- The sand/gravel pack should be placed from the top of HolePlug® at ~935 ft to ~897 ft to provide good flow through the screened interval and allow for any immediate compaction. The annulus will be cemented from the top of the HolePlug® at ~892 ft to the surface. Tamarisk halite (H-3) occurs at SNL-15, not mudstone (M-3).
- Because of the pressure and heat generated by cement in the annulus, the casing will be filled with fresh water prior to cementing to prevent physical damage. The fresh water will be removed (probably by air lift) at an early time after hole completion.

I believe this letter summarizes the hydrological and geological justification for setting the screened interval and preparing SNL-15 for completion.

Sincerely,

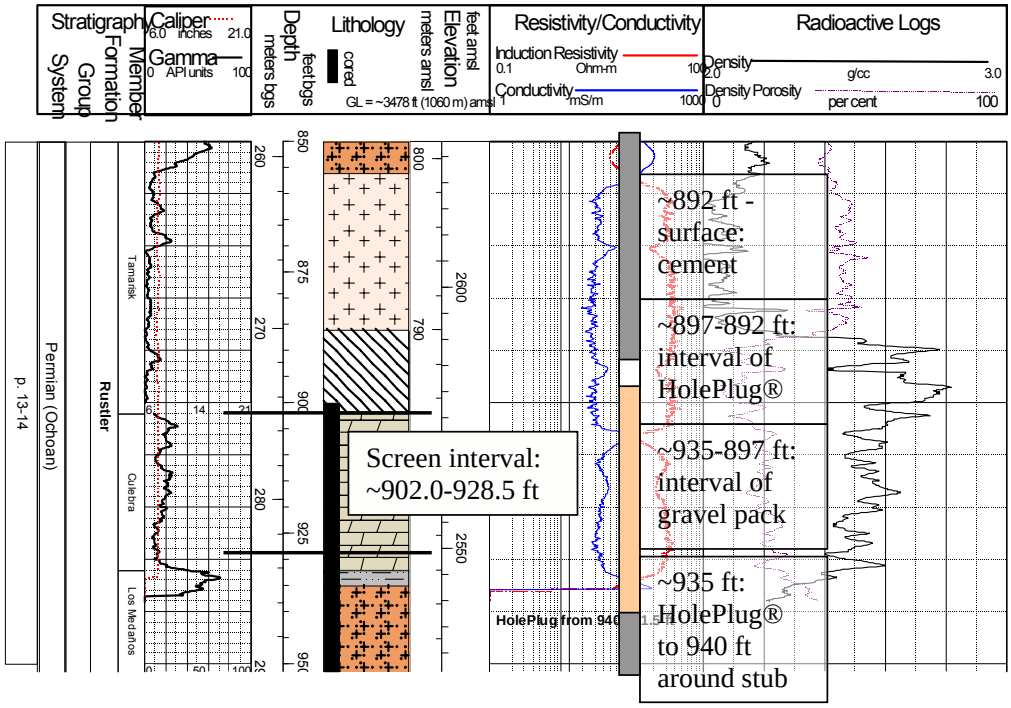
Dennis W. Powers

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

June 6, 2005

Partial Geophysical Log of SNL-15
Showing Completion Intervals



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

August 23, 2005

Rey Carrasco
Geotechnical Engineering
Washington TRU Solutions
Carlsbad, NM 88220

Storage and Retention of Cores and Rock Samples from SNL-15

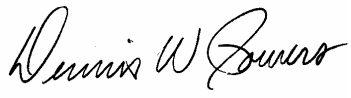
Background
Cores and cutting samples have been collected from drillhole SNL-15 in support of the drilling and testing program to investigate the hydrology of the Culebra Dolomite Member of the Rustler Formation as well as other units of hydrogeological significance to the program. These samples were collected under my supervision, and the chain-of-custody has been maintained by me or WRES personnel. SNL-15 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-15 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-15 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-15 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-15.



Dennis W. Powers

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

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

Revised August 1967

IMPORTANT - READ INSTRUCTIONS ON BACK BEFORE FILLING OUT THIS FORM

APPLICATION FOR PERMIT

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

Date Received 02-07-05 File No. C-3152

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

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

3. The well is to be located in the sw ¼ se ¼ se ¼, Section 26 Township 22 South
   Range 31 East N.M.P.M., or Tract No. n/a of Map No. n/a of the Carlsbad, District,
   on land owned by U.S. Department of the Interior, Bureau of Land Management

4. Description of well: name of driller West Texas Water Well Service
   Outside Diameter of casing < 7 inches; Approximate depth to be drilled 1250 then plugged back to 1000 feet;

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

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

Subdivision	Section	Township	Range	Acres	Owner

7. Additional statements or explanations The intent of this application is to provide authorization to drill a groundwater monitoring well in support of Performance Assessment for the U. S. Department of Energy's Waste Isolation Pilot Plant. This well will be completed in the Culebra Dolomite Member of the Rustler Formation and will not be used to appropriate water for beneficial use. Initial pump tests will be conducted, not to exceed 30 days @ less than or equal to, 20 gal/min. Thereafter, the subject well will be used for water level measurements only.

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

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

By: Harold Johnson

Subscribed and sworn to before me this 7th day of Feb, A.D., 2005

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

#323372

Number of this permit_____

ACTION OF STATE ENGINEER

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

see attached conditions of approval

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

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

Witness my hand and seal this 10th day of February, 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 unsurveyed lands describe by legal subdivision "as projected" from the nearest government survey corners, or describe by metes and bounds and tie survey to some permanent, easily located natural object.

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

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

Roswell Office
1900 WEST SECOND STREET
ROSWELL, NM 88201

STATE OF NEW MEXICO
OFFICE OF THE STATE ENGINEER

Trn Nbr: 323372
File Nbr: C 3152

February 10, 2005

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

Greetings:

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

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

This permit will expire on or before 02/28/06, unless the well has been drilled and the well log filed in this office.

Sincerely,

Mike Stapleton
(505)622-6467

Enclosure

cc: Santa Fe Office

explore

UNIQUE #	DOE U#	DATE RECVD	ADDRESSEE
85061	546700	FEB 14 2005	H Johnson w/ orig att.

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 03152 must be completed and the Well Log filed on or before 02/28/2006.

ACTION OF STATE ENGINEER

Notice of Intention Rcvd: Date Rcvd. Corrected:
Formal Application Rcvd: 02/07/2005 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 10 day of Feb A.D., 2005

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

By: _____
Art Mason

Trn Desc: C 3152 File Number: C 03152
Trn Number: 323372

page: 1

United States Department of the Interior

Bureau of Land Management
Carlsbad Field Office
620 E. Greene Street
Carlsbad, NM 88220
www.nm.blm.gov

IN REPLY REFER TO:
NM-108365
2805(520)owl

MAR 16 2005

U. S. Dept. of Energy, Carlsbad Field Office
P. O. Box 3090
Carlsbad, NM 88221-3090

RIGHT-OF-WAY RESERVATION AMENDMENT

KNOW ALL MEN BY THESE PRESENTS, that in accordance with section 507 of the Federal Land Policy and Management Act of 1976 (90 Stat. 2781, 43 U.S.C. 1767) that the United States of America acting by and through the U. S. Department of the Interior, Bureau of Land Management, does hereby issue and reserve to the U. S. Department of Energy, Carlsbad Field Office, Waste Isolation Pilot Plant (WIPP), a right-of-way amendment for three additional well pads, and access roads for the expressed purpose of conducting groundwater investigations in support of the WIPP, over the following described real property situated in the Counties of Lea and Eddy, State of New Mexico to wit:

SNL – 6	SNL-8	SNL-15
T. 21 S., R. 32 E., NMPM	T. 22 S., R. 31 E., NMPM	T. 22 S., R. 31 E., NMPM
Sec. 7: Lot 4, and SE¼SW¼, SE¼.	Sec. 14: SE¼SE¼.	Sec. 26: SE¼SE¼.

The well site locations contain approximately 1.551 acres (approximately 150' X 150') and the linear features (roads) contain approximately 6408 feet length, 20 feet width, for 2.975 acres. The combined acreage of the site locations and roads are 4.526 acres.

A plat showing the reservation amendment described above is attached hereto as Exhibit A and made a part hereof.

The right-of-way herein granted and reserved is for the full use of the above described property by the U. S. Department of the Energy, Carlsbad Field Office, WIPP, subject to reasonable rules and regulations of the Secretary of the Interior, and to the following terms and conditions:

1. The facility will be constructed, operated, and maintained in accordance with the details specified in the application submitted February 18, 2005.

2. The Bureau of Land Management retains the right to occupy and use the right-of-way, provided such occupancy and use will not unreasonably interfere with the rights granted herein. The Bureau of Land Management may, if the Department of Energy, Carlsbad Field Office, WIPP concurs, grant rights and privileges for the use of the right-of-way to other compatible users including members of the public and other Government Departments and Agencies, States, and local subdivisions thereof.

3. Department of Energy, Carlsbad Field Office, WIPP, will be responsible for the security and day-to-day operation of the facility.

4. Any resources on lands within the right-of-way shall remain under the jurisdiction of the Bureau of Land Management and may be severed or extracted or disposed of only in accordance with applicable law and regulation of the Secretary of the Interior. The extraction, severance, and disposal of any such resources shall be subject to such stipulations, if any, that the Bureau of Land Management and Department of Energy, Carlsbad Field Office, WIPP, agree are needed to avoid unreasonable interference with the use of the land.

5. When and if the Department of Energy, Carlsbad Field Office, WIPP, no longer needs this amended reservation, if jurisdiction is not transferred to another entity, the Department of Energy, Carlsbad Field Office, WIPP, will rehabilitate the land according to the following specifications.

A. All structures, improvements, debris, etc., will be removed.

B. The land will be returned to the original contour.

C. All disturbed surfaces will be reseeded with a seed mixture conducive with Lesser Prairie Chicken habitat.

D. Attached are Special Stipulations for Site Reclamation.

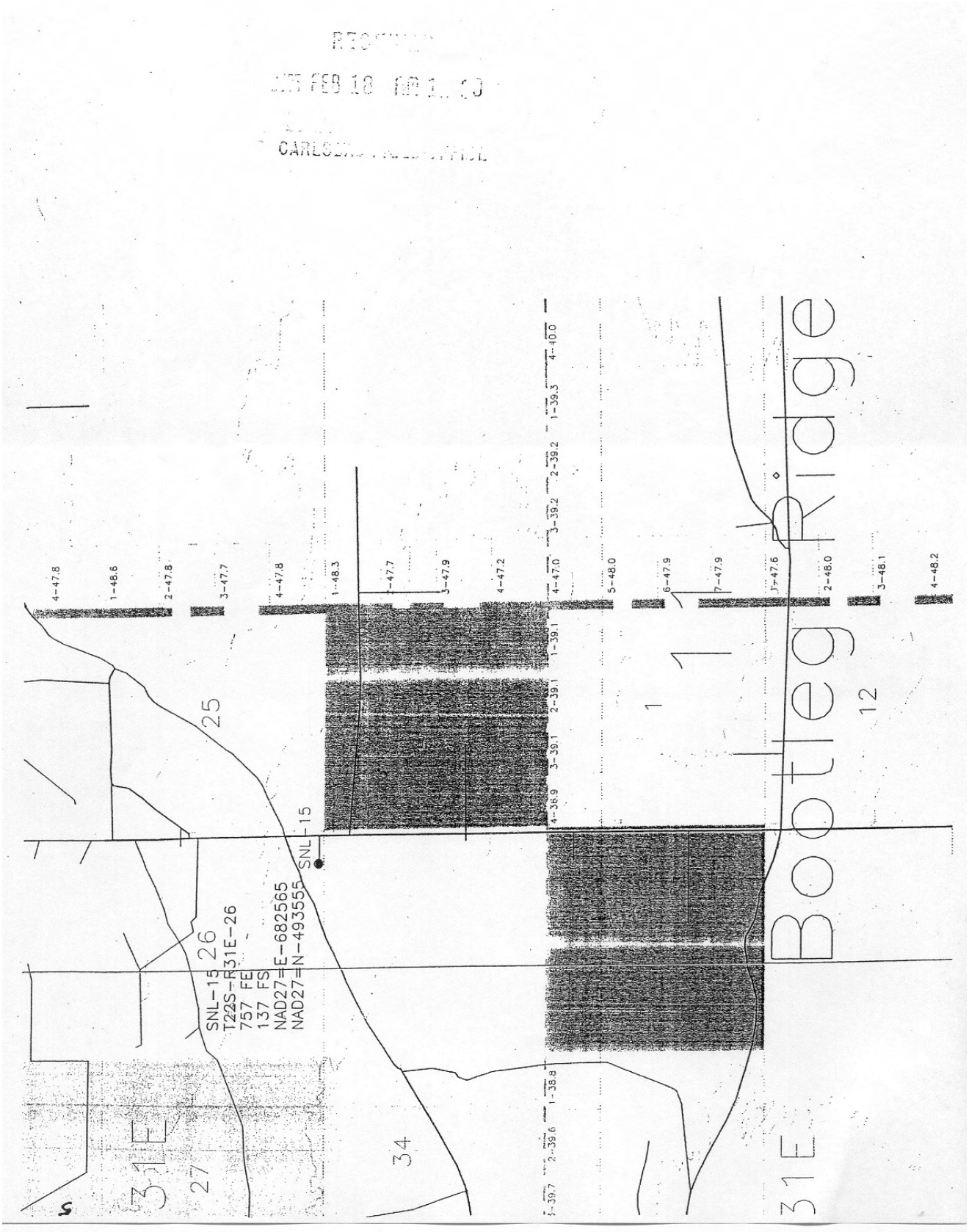
6. The reservation being amended has a 30-year term, commencing on August 30, 2002.

Tony J. Herrell

Tony J. Herrell, Field Manager
Carlsbad Field Office, BLM

3-15-05

Date


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

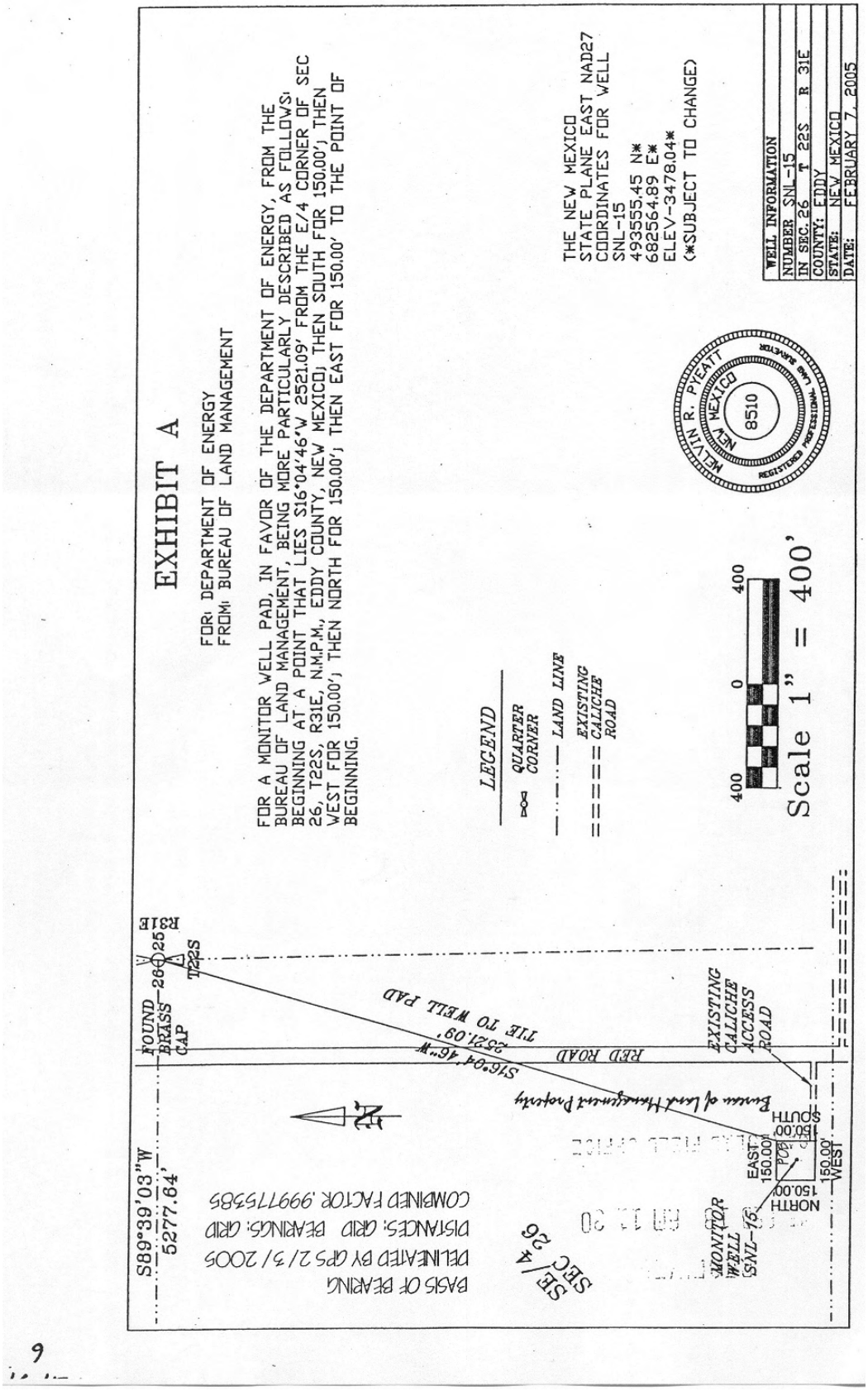


EXHIBIT A
FOR: DEPARTMENT OF ENERGY
FROM: BUREAU OF LAND MANAGEMENT
FOR A MONITOR WELL PAD, IN FAVOR OF THE DEPARTMENT OF ENERGY, FROM THE BUREAU OF LAND MANAGEMENT, BEING MORE PARTICULARLY DESCRIBED AS FOLLOWS: BEGINNING AT A POINT THAT LIES S16°04'46"W 2521.09' FROM THE E/4 CORNER OF SEC 26, T22S, R31E, N.M.P.M., EDDY COUNTY, NEW MEXICO; THEN SOUTH FOR 150.00'; THEN WEST FOR 150.00'; THEN NORTH FOR 150.00'; THEN EAST FOR 150.00' TO THE POINT OF BEGINNING.
LEGEND
QUARTER CORNER
LAND LINE
EXISTING CALICHE ROAD
THE NEW MEXICO
STATE PLANE EAST NAD27
COORDINATES FOR WELL
SNL-15
493555.45 N*
682564.89 E*
ELEV-3478.04*
(*SUBJECT TO CHANGE)
WELL INFORMATION
NUMBER SNL-15
IN SEC. 26 T 22S R 31E
COUNTY: EDDY
STATE: NEW MEXICO
DATE: FEBRUARY 7, 2005
Scale 1" = 400'
400 0 400
MONITOR WELL SNL-15
SE/4 SEC. 26
EAST 150.00'
NORTH 150.00'
SOUTH 150.00'
WEST 150.00'
EXISTING CALICHE ACCESS ROAD
RED ROAD
S16°04'46"W 2521.09' TIE TO WELL PAD
FOUND BRASS CAP
S89°39'03"W 5277.64'
BASIS OF BEARING
DELINEATED BY GPS 2/3/2005
DISTANCES, GRID BEARINGS, GRID
COMBINED FACTOR .99977585
R31E
T22S
25
26
NEW MEXICO
8510
REGISTERED PROFESSIONAL LAND SURVEYOR
NELTON R. PYEATT

EXHIBIT B
March 15, 2005
NM-108365

STIPULATIONS FOR FLPMA SITES

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

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

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

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

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

6. All above-ground structures not subject to safety requirements shall be painted by the holder to blend with the natural color of the landscape. The paint used shall be a color which simulates "Standard Environmental Colors" designated by the Rocky Mountain Five-State Interagency Committee. The color selected for this project is 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:

The Authorized Officer will be contacted for the well pads and access road restoration instructions when the wells are ready for final abandonment procedures. At that time full restoration of the sites (150' X 150') will be addressed.

EXHIBIT C

BLM Serial No.: NM-108365
Company Reference:

Seed Mixture for LPC Sand/Shinnery Sites

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

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

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

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

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

*Pounds of pure live seed:

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

SENM-S-22

PRAIRIE CHICKENS

No surface use is allowed during the following time periods; unless otherwise specified, this stipulation does not apply to operation and maintenance of production facilities.

On the following lands:

T. 21 S., R. 32 E., NMPM
Sec. 7: All

T. 22 S., R. 31 E., NMPM
Sec. 14: All
Sec. 26: All

For the purpose of: Protecting Prairie Chickens:

Drilling for oil and gas, and 3-D geophysical exploration operations will not be allowed in Lesser Prairie Chicken Habitat during the period of March 15 through June 15, each year. During that period, other activities that produce noise or involve human activity, such as the maintenance of oil and gas facilities, geophysical exploration other than 3-D operations, and pipeline, road, and well pad construction, will be allowed except between 3:00 a.m. and 9:00 a.m. The 3:00 a.m. and 9:00 a.m. restriction will not apply to normal, around-the-clock operations, such as venting, flaring, or pumping, which do not require a human presence during the period. Additionally, no new drilling will be allowed within up to 200 meters of leks know at the time of permitting. Normal vehicle use on existing roads will not be restricted. Exhaust noise from pump jack engines must be muffled or otherwise controlled so as not to exceed 75 db measured at 30 feet from the source of the noise.

Bureau of Land Management
Carlsbad Field Office

SENM-S-22
December 1997

Revised June 1972

STATE ENGINEER OFFICE

WELL RECORD

Section 1. GENERAL INFORMATION

(A) Owner of well WASHINGTON TRU SOLUTIONS Owner's Well No. SNL-15
Street or Post Office Address P.O. BOX 2078
City and State CARLSBAD, NEW MEXICO 88221

Well was drilled under Permit No. C 3152 and is located in the:

a. SE ¼ SE ¼ ¼ ¼ of Section 26 Township 22S Range 31E N.M.P.M.

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

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

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

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

Address 3410 MANKINS ODESSA, TEXAS 79764

Drilling Began 6-1-05 Completed 6-7-05 Type tools MUD ROTARY Size of hole 7-7/8 in.

Elevation of land surface or _____ at well is 3478 ft. Total depth of well 938 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)
902	932	30	BROWN DOLOMITE CULEBRA	

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
8-5/8	22.38	Welded	3' AGL	40	43			
2-1/2 FIBERGLASS	1.75	4	2-1/2' AGL	935	937-1/2		902	.070 SCREEN 928.5

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
938	935	7-7/8 2-1/2 CSG	1 BAG HOLE PLUG		
950	938	7-7/8	4-1/2 BAGS HOLE PLUG		TOP LOAD
0	891	7-7/8 2-1/2 CSG		270	TRIMMIE

Section 5. PLUGGING RECORD

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

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

FOR USE OF STATE ENGINEER ONLY

Date Received

Quad _____ FWL _____ FSL _____

File No. _____ Use _____ Location No. _____

From	To	Thickness in Feet	Color and Type of Material Encountered
0	10	10	CONSTRUCTION FILL & DUNE SAND
10	20	10	WHITE CALICHE & CALCAREOUS SAND (SANTA ROSA)
20	86	66	WEAK RED SANDSTONE & LAMINATED CLAYSTONE (TRIASSIC SANTA ROSA FORMATION)
86	624	538	RED TO REDDISH BROWN SANDY SILTSTONE, SILTY CLAYSTONE & FINE SANDSTONE (PERMOTRIASSIC DEWEY LAKE FORMATION)
624	698	74	GRAY ANHYDRITE BEDS WITH INTERMEDIATE HALITE & REDDISH BROWN ARGILLACEOUS HALITE (FORTY-NINER MEMBER OF RUSTLER FORMATION)
698	724	26	LIGHT OLIVE GRAY TO WHITE GYPSIFEROUS DOLOMITE (MAGENTA DOLOMITE MEMBER OF RUSTLER FORMATION)
724	902	178	GRAY ANHYDRITE & GYPSUM BEDS WITH INTERMEDIATE HALITE, POLYHALITE & GRAY TO REDDISH BROWN SILTY HALITE (TAMARISK MEMBER OF RUSTLER FORI
902	932	30	BROWN DOLOMITE W/ANHYDRITE NODULES & HALITE FRACTURE & PORE FILLINGS (CULEBRA DOLOMITE MEMBER OF THE RUSTLER FORMATION)
932	935	3	DARK GRAY GYPSIFEROUS CLAYSTONE & SILTSTONE (UPPERMOST LOS MEDANOS MEMBER OF THE RUSTLER FORMATION)
935	951.5	16.5	CLEAR, COARSE HALITE & REDDISH BROWN ARGILLACEOUS TO SILTY HALITE (UPPER LOS MEDANOS MEMBER OF THE RUSTLER FORMATION)

Section 7. REMARKS AND ADDITIONAL INFORMATION

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

Tommy Keith
Driller

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

Appendix E
Archeological Clearance Report

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

1. (For BLM Use) **BLM Report No.**	**2. (For BLM Use)** **Reviewer's Initials/Date**_____ **Accepted ( ) Rejected ( )**	**3. NMCRIS Number:** 91630
4. Type of Report: **Negative (X)** **Positive ( )**		
5. Title of Report: A Cultural Resource Survey for the SNL-6, SNL-8, and SNL-15 Well Pads		**6. Fieldwork Date(s):** February 2, 2005
Author(s): Theresa Straight		**7. Report Date:** February 2, 2005
8. Consultant Name/Address: Mesa Field Services **Direct Charge:** Theresa Straight **Field Personnel Names:** Sean Simpson **Address:** P.O. Box 3072 Carlsbad, New Mexico 88221-3072 **Phone (**505**)** 628-8885		**9. Cultural Resource Permit No.:** 153-2920-03-N **10. Consultant Report No.:** MFS-1122
11. Customer Name: Westinghouse TRU Solutions, LLC **Responsible Individual:** Ron Richardson **Address:** P.O. Box 2078 Carlsbad, NM 88221 **Phone:** (505) 234-8395		**12. Customer Project No.:** P.O. 107596

13. Land Status	**BLM**	**State**	**Private**	**Other**	**Total**
a. Area Surveyed (acres)	8.44				8.44
b. Area of Effect (acres)	1.55				1.55

14. Linear **Length** N/A **Width** N/A
Block **Length** 350 ft **Width** 350 ft (each)

15. Location (Map[s] Attached):

a. State: New Mexico

b. County: Eddy and Lea Counties

c. BLM Office: Carlsbad Field Office

d. Nearest City or Town: Loving, NM

e. Legal Description: T21S, R32E, Section 7: N½ SE¼(SNL-6)
T22S, R31E, Section 14: SE¼ SE¼, Section 13: SW¼ SW¼ (SNL-8)
T22S, R31E, Section 26: SE¼ SE¼, Section 35: NE¼ NE¼ (SNL-15)

f. Well Pad Footages: approx. 1,750 ft FSL; 1,400 ft FEL Sec. 7, T21S, R32E (SNL-6)
approx. 900 ft FSL; 100 ft FEL Sec. 14, T22S, R31E (SNL-8)
approx 50 ft FSL; 700 ft FEL Sec. 26, T22S, R31E (SNL-15)

g. USGS 7.5' Map Name(s), Date(s), and Code(s): The Divide, NM 1984 (32103-D6)
Bootleg Ridge, NM 1984 (32103-C6)

16. Project Data:

a. Records Search: **Date(s) of BLM File Review:** February 1, 2005 **Name of Reviewer(s):** Theresa Straight
Date(s) of ARMS Data Review February 1, 2005 **Name of Reviewer(s):** Theresa Straight
Findings (see Field Office requirements to determine area to be reviewed during records search): One previously recorded site, LA 30766, is within 500 ft of the SNL-6 well pad. This site was not encountered during the survey. No other sites are within 0.25 mile of any of the well locations.

b. Description of Undertaking: Westinghouse TRU Solutions plans to build three monitoring wells. They are the SNL-6, SNL-8, and SNL-15. No plat sheets were provided; however, UTM grid coordinates were given for each location. They are as follows: SNL-6 (NAD 27; Zone 13) 621250 E/ 3595385 N, SNL-8 (NAD 27, Zone 13) 618524 E/ 3583795 N, and SNL-15 (NAD 27, Zone 13) 618359 E/ 3580335 N. Each well location will be 150 ft square, yet a 350 ft square was surveyed to ensure the protection of cultural resources. The project totaled 8.44 acres, all of which is located on land owned and administered by the BLM-CFO.

c. Environmental Setting (NRCS soil designation; vegetative community; elevation; etc.): The project area is located east of Livingston Ridge. The terrain is relatively flat, varying from a grade of 0.8 percent to a grade of 1.4 percent. The elevation varies from 3,480 ft to 3,640 ft above mean sea level. The soils area of the Kermit-Berino and Pyote-Maljamar-Kermit associations as defined by the Soil Conservation Service of the U.S. Department of Agriculture. Local vegetation is typical of Chihuahuan Desert Scrub and includes mesquite, grasses, and yucca. Due to this vegetative cover, ground surface visibility averaged 85 percent at the time of the survey.

Climatic information was obtained from the Western Regional Climate Center online database for the Waste Isolation Pilot Plant (WIPP). From 1986 to 2002 WIPP received an average annual precipitation of 12.68 inches. July through September were the wettest months while January through March were the driest. WIPP has an average annual high temperature of 80.1 degrees Fahrenheit and an average annual low temperature of 48.9 degrees (F). July is the warmest month with an average high of 98.0 degrees (F) and December is the coldest month with an average high of 60.0 degrees (F).

d. Field Methods (transect intervals; crew size; time in field; etc.): A crew of one spent 4 hours surveying the project area. A 15 m wide transect interval was used.

e. Artifacts Collected?: None

17. Cultural Resource Findings: No cultural material was encountered during the survey.

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

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

18. Management Summary (Recommendations): Because no cultural material was encountered, archaeological clearance is recommended for the project as staked. If any cultural material is encountered during construction activities, work at that location should stop and archaeologists with the BLM-CFO should be notified.

19.

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

Responsible Archaeologist_____ _____
Signature **Date**

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

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

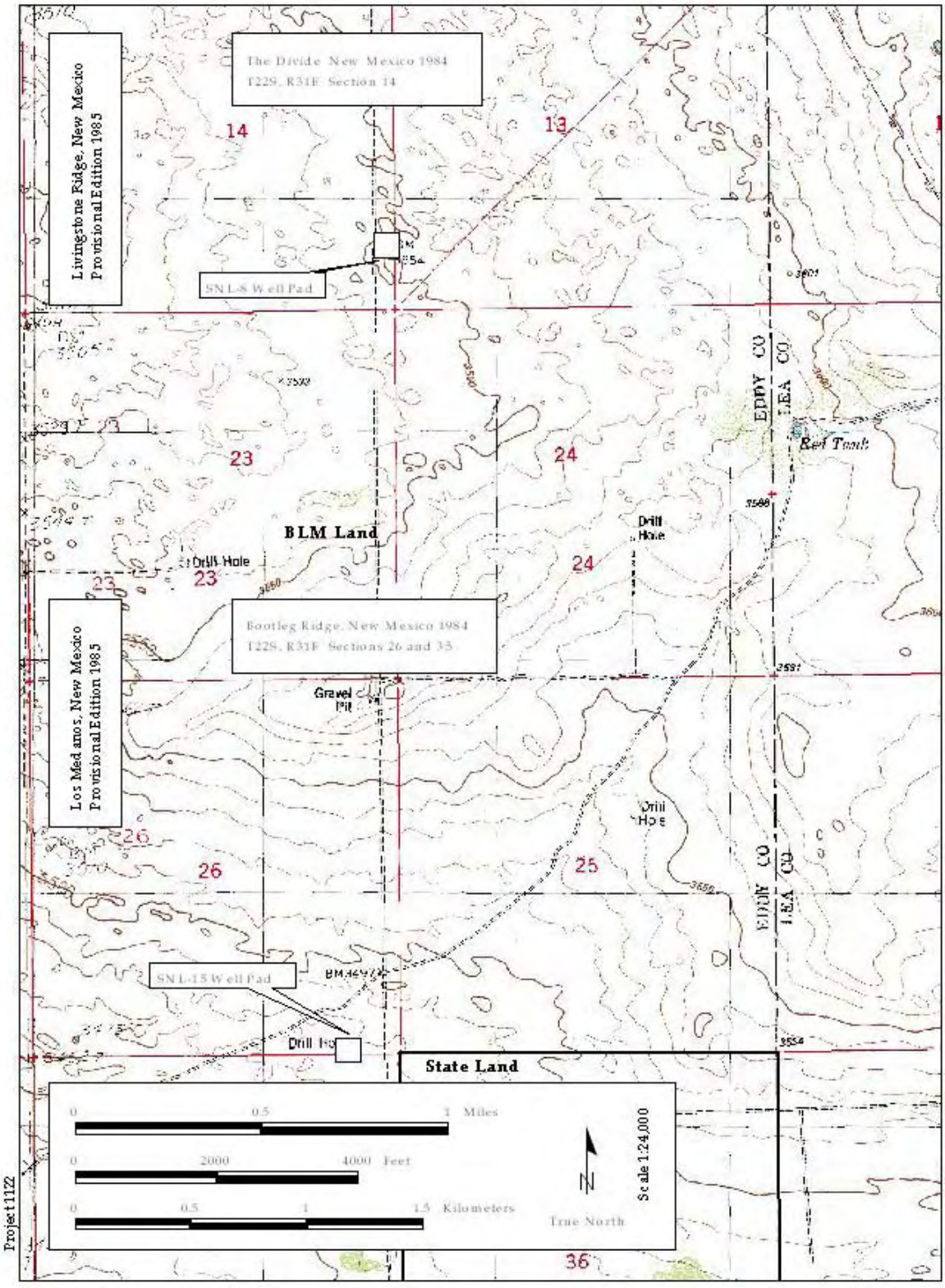


Figure 1. Project Area Map

Mesa Field Services

Appendix F
Photograph Logs

Digital photographs were taken of the cores from SNL-13. A listing of consecutive photos, beginning with the lower Tamarisk Member of the Rustler Formation and ending with the upper Los Medaños Member of the Rustler Formation, has been compiled and is included here in Appendix F. 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-15_Core001.jpg	6/5/05	SNL-15 drillpad; T22S, R31E, sec 26	Close-up photo of Tamarisk Mbr core, 900.0 - 901.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-15_Core002.jpg	6/5/05	SNL-15 drillpad; T22S, R31E, sec 26	Close-up photo of Tamarisk Mbr core, 900.9 - 902.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-15_Core003.jpg	6/5/05	SNL-15 drillpad; T22S, R31E, sec 26	Close-up photo of Tamarisk Mbr core, 901.9 - 903.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-15_Core004.jpg	6/5/05	SNL-15 drillpad; T22S, R31E, sec 26	Close-up photo of Tamarisk Mbr core, 902.9 - 904.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-15_Core005.jpg	6/5/05	SNL-15 drillpad; T22S, R31E, sec 26	Close-up photo of Tamarisk Mbr core, 903.9 - 905.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-15_Core006.jpg	6/5/05	SNL-15 drillpad; T22S, R31E, sec 26	Close-up photo of Tamarisk/Culebra Dolomite Mbrs core, 904.9 - 906.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-15_Core007.jpg	6/5/05	SNL-15 drillpad; T22S, R31E, sec 26	Close-up photo of Culebra Dolomite Mbr core, 905.9 - 907.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-15_Core008.jpg	6/5/05	SNL-15 drillpad; T22S, R31E, sec 26	Close-up photo of Culebra Dolomite Mbr core, 906.9 - 908.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-15_Core009.jpg	6/5/05	SNL-15 drillpad; T22S, R31E, sec 26	Close-up photo of Culebra Dolomite Mbr core, 907.9 - 909.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-15_Core010.jpg	6/5/05	SNL-15 drillpad; T22S, R31E, sec 26	Close-up photo of Culebra Dolomite Mbr core, 908.9 - 910.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-15_Core011.jpg	6/5/05	SNL-15 drillpad; T22S, R31E, sec 26	Close-up photo of Culebra Dolomite Mbr core, 909.9 - 911.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-15_Core012.jpg	6/5/05	SNL-15 drillpad; T22S, R31E, sec 26	Close-up photo of Culebra Dolomite Mbr core, 911.1 - 912.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-15_Core013.jpg	6/5/05	SNL-15 drillpad; T22S, R31E, sec 26	Close-up photo of Culebra Dolomite Mbr core, 911.9 - 913.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-15_Core014.jpg	6/5/05	SNL-15 drillpad; T22S, R31E, sec 26	Close-up photo of Culebra Dolomite Mbr core, 912.9 - 914.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-15_Core015.jpg	6/5/05	SNL-15 drillpad; T22S, R31E, sec 26	Close-up photo of Culebra Dolomite Mbr core, 913.9 - 915.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-15_Core016.jpg	6/5/05	SNL-15 drillpad; T22S, R31E, sec 26	Close-up photo of Culebra Dolomite Mbr core, 914.9 - 916.1 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-15_Core017.jpg	6/5/05	SNL-15 drillpad; T22S, R31E, sec 26	Close-up photo of Culebra Dolomite Mbr core, 915.9 - 917.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-15_Core018.jpg	6/5/05	SNL-15 drillpad; T22S, R31E, sec 26	Close-up photo of Culebra Dolomite Mbr core, 916.9 - 918.0 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-15_Core019.jpg	6/5/05	SNL-15 drillpad; T22S, R31E, sec 26	Close-up photo of Culebra Dolomite Mbr core, 917.9 - 919.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-15_Core020.jpg	6/5/05	SNL-15 drillpad; T22S, R31E, sec 26	Close-up photo of Culebra Dolomite Mbr core, 918.9 - 920.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-15_Core021.jpg	6/5/05	SNL-15 drillpad; T22S, R31E, sec 26	Close-up photo of Culebra Dolomite Mbr core, 919.9 - 921.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-15_Core022.jpg	6/5/05	SNL-15 drillpad; T22S, R31E, sec 26	Close-up photo of Culebra Dolomite Mbr core, 920.9 - 922.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-15_Core023.jpg	6/5/05	SNL-15 drillpad; T22S, R31E, sec 26	Close-up photo of Culebra Dolomite Mbr core, 921.9 - 923.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-15_Core024.jpg	6/5/05	SNL-15 drillpad; T22S, R31E, sec 26	Close-up photo of Culebra Dolomite Mbr core, 923.0 - 924.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-15_Core025.jpg	6/5/05	SNL-15 drillpad; T22S, R31E, sec 26	Close-up photo of Culebra Dolomite Mbr core, 924.0 - 925.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-15_Core026.jpg	6/5/05	SNL-15 drillpad; T22S, R31E, sec 26	Close-up photo of Culebra Dolomite Mbr core, 925.0 - 926.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-15_Core027.jpg	6/5/05	SNL-15 drillpad; T22S, R31E, sec 26	Close-up photo of Culebra Dolomite Mbr core, 925.9 - 927.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-15_Core028.jpg	6/5/05	SNL-15 drillpad; T22S, R31E, sec 26	Close-up photo of Culebra Dolomite Mbr core, 926.9 - 927.4 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-15_Core029.jpg	6/5/05	SNL-15 drillpad; T22S, R31E, sec 26	Close-up photo of Culebra Dolomite Mbr core, 927.4 - 928.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-15_Core030.jpg	6/5/05	SNL-15 drillpad; T22S, R31E, sec 26	Close-up photo of Culebra Dolomite Mbr core, 927.9 - 929.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-15_Core031.jpg	6/5/05	SNL-15 drillpad; T22S, R31E, sec 26	Close-up photo of Culebra Dolomite Mbr core, 928.9 - 930.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-15_Core032.jpg	6/5/05	SNL-15 drillpad; T22S, R31E, sec 26	Close-up photo of Culebra Dolomite Mbr core, 929.9 - 931.1 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-15_Core033.jpg	6/5/05	SNL-15 drillpad; T22S, R31E, sec 26	Close-up photo of Culebra Dolomite Mbr core, 930.9 - 932.1 ft bgl, with markings, scale; strap obscures part of photo	DW Powers Consultant to WTS
SNL-15_Core034.jpg	6/5/05	SNL-15 drillpad; T22S, R31E, sec 26	Close-up photo of Culebra Dolomite Mbr core, 931.9 - 933.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-15_Core035.jpg	6/5/05	SNL-15 drillpad; T22S, R31E, sec 26	Close-up photo of Culebra Dolomite Mbr core, 932.9 - 934.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-15_Core036.jpg	6/5/05	SNL-15 drillpad; T22S, R31E, sec 26	Close-up photo of Culebra Dolomite Mbr core, 933.9 - 935.0 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-15_Core037.jpg	6/5/05	SNL-15 drillpad; T22S, R31E, sec 26	Close-up photo of Culebra Dolomite/Los Medaños Mbrs core, 935.0 - 936.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-15_Core038.jpg	6/5/05	SNL-15 drillpad; T22S, R31E, sec 26	Close-up photo of Los Medaños Mbr core, 935.9 - 937.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-15_Core039.jpg	6/5/05	SNL-15 drillpad; T22S, R31E, sec 26	Close-up photo of Los Medaños Mbr core, 936.9 - 938.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-15_Core040.jpg	6/5/05	SNL-15 drillpad; T22S, R31E, sec 26	Close-up photo of Los Medaños Mbr core, 937.9 - 939.1ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-15_Core041.jpg	6/5/05	SNL-15 drillpad; T22S, R31E, sec 26	Close-up photo of Los Medaños Mbr core, 938.9 - 940.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-15_Core042.jpg	6/5/05	SNL-15 drillpad; T22S, R31E, sec 26	Close-up photo of Los Medaños Mbr core, 939.9 - 941.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-15_Core043.jpg	6/5/05	SNL-15 drillpad; T22S, R31E, sec 26	Close-up photo of Los Medaños Mbr core, 940.9 - 942.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-15_Core044.jpg	6/5/05	SNL-15 drillpad; T22S, R31E, sec 26	Close-up photo of Los Medaños Mbr core, 941.9 - 943.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-15_Core045.jpg	6/5/05	SNL-15 drillpad; T22S, R31E, sec 26	Close-up photo of Los Medaños Mbr core, 942.9 - 944.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-15_Core046.jpg	6/5/05	SNL-15 drillpad; T22S, R31E, sec 26	Close-up photo of Los Medaños Mbr core, 943.9 - 945.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-15_Core047.jpg	6/5/05	SNL-15 drillpad; T22S, R31E, sec 26	Close-up photo of Los Medaños Mbr core, 944.9 - 946.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-15_Core048.jpg	6/5/05	SNL-15 drillpad; T22S, R31E, sec 26	Close-up photo of Los Medaños Mbr core, 945.9 - 947.1 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-15_Core049.jpg	6/5/05	SNL-15 drillpad; T22S, R31E, sec 26	Close-up photo of Los Medaños Mbr core, 946.9 - 948.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-15_Core050.jpg	6/5/05	SNL-15 drillpad; T22S, R31E, sec 26	Close-up photo of Los Medaños Mbr core, 947.9 - 949.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-15_Core051.jpg	6/5/05	SNL-15 drillpad; T22S, R31E, sec 26	Close-up photo of Los Medaños Mbr core, 948.9 - 950.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-15_Core052.jpg	6/5/05	SNL-15 drillpad; T22S, R31E, sec 26	Close-up photo of Los Medaños Mbr core, 949.9 - 951.1 ft bgl, with markings, scale	DW Powers Consultant to WTS
SNL-15_Core053.jpg	6/5/05	SNL-15 drillpad; T22S, R31E, sec 26	Close-up photo of Los Medaños Mbr core, 950.9 - 951.5 ft bgl, with markings, scale	DW Powers Consultant to WTS

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

Ronny Keith (r) of West Texas Water Well Service and John Wood (l) of Diamond Oil Well Drilling Company during coring of SNL-15. June 5, 2005. Photo by Dennis W. Powers.

Appendix G
Geophysical Logs

Geophysical logging of SNL-15 was conducted by Jet West Geophysical Services, LLC, 2550 La Plata Highway, Farmington, NM, 87499-3522, on June 6, 2005. The operator was Al Henderson. Copies of the logs are maintained by Washington Regulatory and Environmental Services, Environmental Monitoring and Hydrology Section, for the WIPP project. A CD-ROM is being retained that includes:

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

The following geophysical logs were obtained:

- Caliper
- Natural gamma
- Density-porosity
- Induction resistivity
- Induction conductivity

SNL-15 had been cored and drilled to ~950 ft, plugged back to ~938 ft with bentonite, and reamed to 940 ft at the time of logging. A conductor casing had been placed to a depth of 39.5 ft bgl, with a stickup of 0.5 ft. There was no detectable brine in the drillhole at the time of logging. SNL-15 was drilled with air.

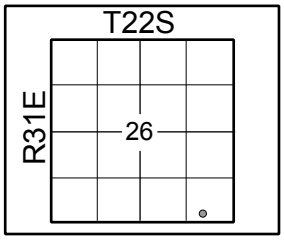
The caliper log was used for estimating material volume placed in the annulus between fiberglass reinforced plastic casing and the drillhole wall.

The reference point (0 ft depth) for geophysical logging is the top of the connector on the surface conductor casing and is ~ 0.5 ft above drill pad level. This point was assigned an elevation of 3,478 ft amsl on the logs, based on the predrilling survey of the well pad. A benchmark placed near the drillhole after completion has an elevation of 3,477.94 ft amsl (see Fig. 1-5 and Table 1-1 in the main text) based on a resurvey in 2006. [The benchmark from an earlier survey has not been replaced.] A rounded elevation of 3,478 ft amsl for the reference point used in the text is appropriate for the measurements based on geophysical logs.

Jet West Geophysical Services logging vehicle (right) set up and logging SNL-15 on June 6, 2005. The top of the connector (below) is the reference point (0 ft depth) for logging and setting casing. The photo below taken Septmeber 10, 2005, shows the completed well configuration and the top of the connector.

Figure 2-1
Well Record SNL-15 (C-3152)

Company: Washington TRU Solutions LLC
Well: SNL-15 (C-3152)
Section: 26 Twp: T22S Rge: R31E
Location: 102 ft from south line (fsl)
807 ft from east line (fel)



Reference point
Log measured from: top of connector on conductor casing (gl)
Drilling measured from: gl
Permanent Datum: benchmark (resurveyed 2007)

Elevation
KB:
DF:
GL: 3478 ft amsl
(benchmark: 3477.94)

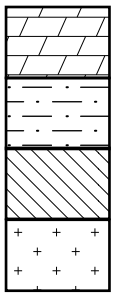
Drilling contractor: West Texas Well Water Service
Coring contractor: Diamond Oil Well Drilling Co.
Geophysical logs: Al Henderson
Jet West Geophysical Services, LLC (NM)
Geologist: Dennis W. Powers
Spud date: June 1, 2005
Completion date: June 7, 2005
Total depth (TD): 950 ft bgl (driller log)

Casing Record
Conductor: 40 ft
8.625 inch steel
Casing: 2.48 inch i.d.
fiberglass reinforced
plastic to 935 ft bgl
Screened interval:
928.5-902 ft bgl

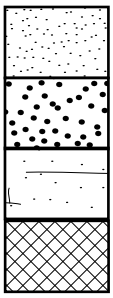
Geophysical Logs Date: June 6, 2005
Micro/Laterolog/Induction/SP: 0-936 ft
Gamma/Fluid: 0-936 ft
Caliper: 0-934 ft
Density/Neutron: 0-938 ft

Type fluid in hole: air
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

SNL-15 Well Log Headers