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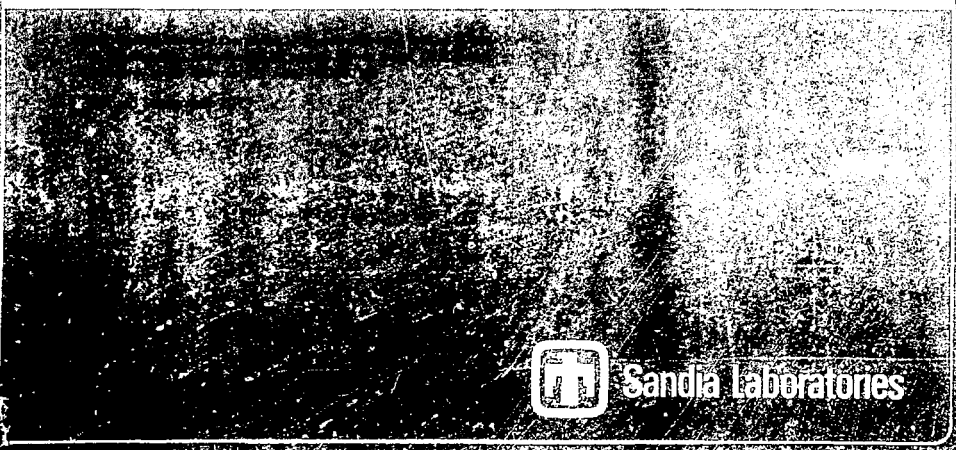
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Basic Data Report for Drillhole WIPP 29 (Waste Isolation Pilot Plant - WIPP)

13/12/79

Sandia Laboratories and
United States Geological Survey



Sandia Laboratories

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1.0. SUMMARY

WIPP 29 was drilled in Nash Draw (SE 1/4, Sec. 34, T22S, R29E) in King County, New Mexico, to determine the effects of fluid flow and dissolution features above undisturbed parts of the Alamo Formation. Determination of dissolution rates will help to predict volumes and provide short-term (geologically) estimates of WIPP gas generation. The borehole encountered, from top to bottom, unaged Ebel Lignite beds of 112' with fill material for part, Dewey Lake (at base of 1981), upper Alamo Formation (131'), and the upper 654' of the lower Alamo. A dissolution residue, 165' thick, is at the top of the lower Alamo, overlying halite-rich beds. In addition to the 1981, two 1982 borehole cores from the surface to total depth (1981) and the final log were used to measure acoustic velocities, density, magnetic susceptibility, and electrical resistivity. An interpretive report on the data from Nash Draw will be based on combined borehole basin data, petrographic, and laboratory analyses of Nash Draw rocks and fluids.

The WIPP is to demonstrate (through verification and display) technology for transuranic defense waste and fission by-product to a repository. The WIPP will also provide retrieval facilities for interactions between high-level waste and host rock.

2.0 INTRODUCTION

by

D. W. Powers and S-E. Shaffer¹

The introduction describes background information on the Waste Isolation Pilot Plant (WIPP) and the investigations in Nash Draw which include WIPP 29.

2.1 The Purpose of WIPP

The purpose of the WIPP is distinct from that of several other projects for the disposal of radioactive waste. The WIPP is planned to demonstrate disposal technology for the transuranic (TRU) waste resulting from the nation's defense programs of over 30 years. After a period (1-10 years) of limited (pilot) operation it is anticipated that the WIPP will be converted to a full-scale repository for permanent disposal of defense TRU waste. The WIPP plans also include a research facility to examine, on a large scale, the interactions between bedded salt and high-level radioactive waste resulting from thermal and radiation fluxes. A Department of Energy (DOE) Task Force has recommended that WIPP also be used to demonstrate surface and subsurface methods of handling, storing and disposing of up to 1,000 canisters of spent reactor fuel; however, a decision on this recommendation has not been made at this time. DOE has expressed an intent to request licensing of the WIPP by the Nuclear Regulatory Commission (NRC), but this policy is presently under discussion between the DOE and Congress.

Additional information on the WIPP and characterization of the WIPP site may be found in Powers, et. al. (1978).

2.2 The Purpose of WIPP Benchholes in Nash Draw

The origin of Nash Draw, located several miles west of the WIPP site, has most commonly been attributed to solution of underlying soluble

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subsidence and subsidence of the overlying rocks (e.g., Vine, 1963; MacKenzie, 1971). The concern with the development of Nash Draw is to determine the dissolution rates and/or processes such that the long-term threat to the WIPP will not be overstated. Bachman and Johnson (1973) estimated the lateral movement of the salt dissolution front at 6 to 8 miles per million years since the end of Geallala time. Bachman (1974) estimated the average rate of vertical dissolution in the area of Nash Draw over the past 600,000 years; that rate is about 330 feet per million years. Piper (1973) estimated the vertical dissolution rate as about 160 feet per million years; Swenson (in Bachman and Johnson, 1973) independently estimated the rate of vertical dissolution as about 500 feet per million years. Bachman (1976) recognizes additional, older episodes of dissolution in southeastern New Mexico which imply that the earlier rates may be too high over the shorter time period. The estimated dissolution as average rates imply little apparent long-term threat to the WIPP.

The important problem remaining then is to determine the short-term dissolution rates to assess any threat to the WIPP. The dissolution which occurred may be episodic rather than continuous. The Nash Draw boreholes (WIPP 25 through 30) are a direct approach to determining the processes and rates over shorter times. The processes can be determined by direct analysis of the core and borehole information. Stratigraphic changes can reveal the affected beds and general time frame. Mineralogical and geochemical analyses of dissolution products may indicate process involved. Hydrologic analysis is to determine if dissolution is currently active. The analysis of data from all boreholes may be combined with other data sources to interpret these processes and rates.

This is a report of basic geological and hydrological data from WIPP 29 as a part of the investigation of dissolution in Nash Draw.

Additional details regarding the background and justification for WIPP 29 are found in Appendix A.

1.0 GEOLOGICAL DATA

by

R. P. Snyder¹ and A. F. McIntyre²

1.1 Abstract

Borehole WIPP 29 was drilled in eastern Eddy County, New Mexico, in August, 1978. It penetrated unnamed Pleistocene deposits and the Dewey Lake Red Beds, the Rustler Formation and part of the Salado Formation, all of Permian age. Detailed lithologic and geophysical logs of the borehole are presented in this chapter.

1.2 Introduction

Borehole WIPP 29 is one of a series of exploratory boreholes drilled for: (1) determine the stratigraphy of near-surface formations, (2) examine the relationship between subsurface structure and surficial features and deposits, and (3) investigate the dissolution of soluble rocks (rock salt, gypsum, and dolomite) by groundwater.

The exploratory drilling was done on behalf of the WIPP (Waste Isolation Pilot Plant) Project Office of the DOE (U.S. Department of Energy).

1.3 Description of WIPP 29

WIPP 29 is located in central eastern Eddy County, NM, in the SE 1/4 Sec. 34, T22S, R29E (Figure 1). The borehole was drilled during October, 1978, to a depth of 378.2 feet, measured from a land surface altitude of 2,977 feet above MSL (mean sea level). Consecutive cores were taken from the surface to a depth of 376 feet. Shelby tubes (hollow metal cylinders) were used in the top five feet of the hole. These tubes are driven downward with no rotation of tube, and they retain more of the unconsolidated surficial material than would a conventional rotating core barrel. The cores were examined and logged at the drill site, and a

¹U.S. Geological Survey, Denver, CO.

²Fenix & Scisson, Inc., Carlsbad, NM.

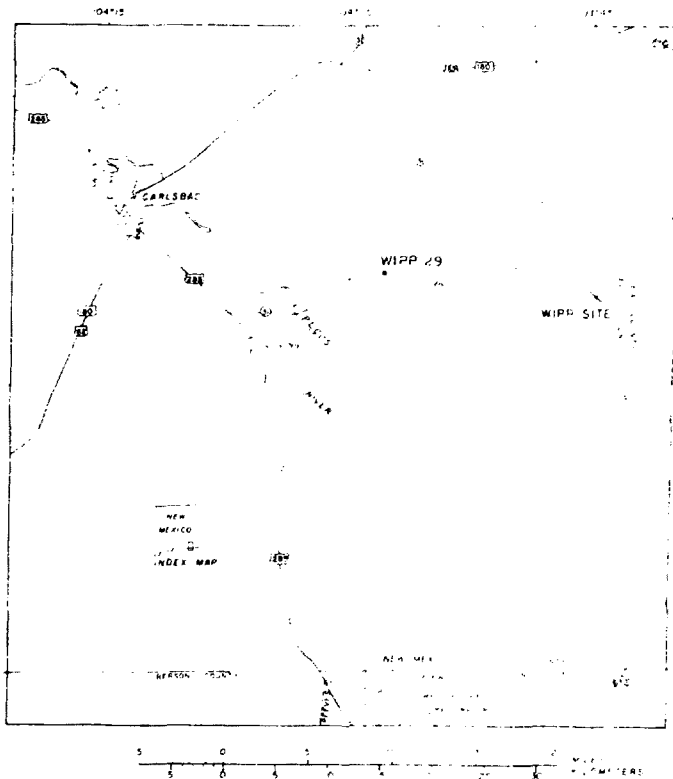


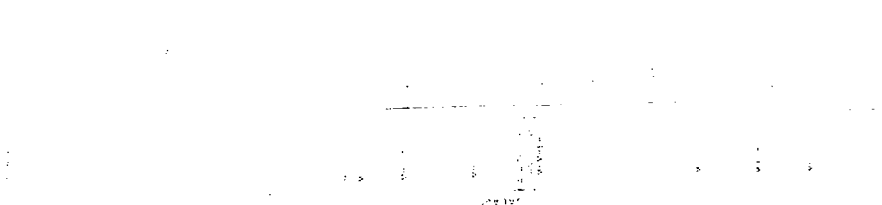
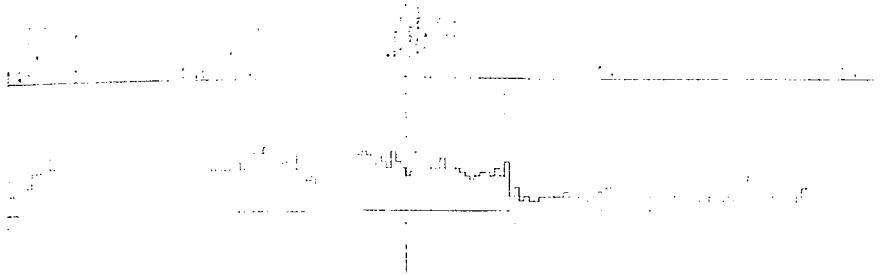
Figure 1.--Index map showing location of borehole WIPP-29.

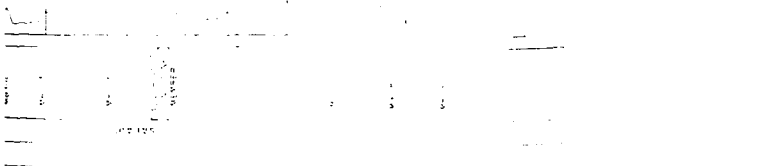
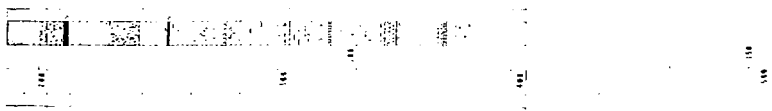
stratigraphic correlation log of the borehole was prepared. This log is Table 1 by A. P. McIntyre and J. L. Gonzales, of P&S (Fenix & Sons, Inc.). The identification of rock units was made in collaboration with G. L. Thompson of the USGS (U.S. Geological Survey). The abridged borehole log that is given in Table 1, and the stratigraphic summary of the hole in Figure 2.

As part of the exploratory work, geophysical logs were taken. The logs were not run to total depth (TD) because of hole problems. The logs were made to facilitate the identification and correlation of rock units and the identification of mineralogical types (dolomite, anhydrite, polyhalite, and halite), and to provide a depth determination, the extent of that indicated by oriented measurements. For this purpose, the geophysical logs included (1) a gamma-ray curve that recorded variations in the distribution of potassium and other naturally occurring elements, (2) a gamma-gamma curve that recorded variations in the density, and (3) a neutron curve that recorded variations in the distribution of hydrogen.

Corehole WIPP 10 penetrated unmetamorphosed granite and limestone of the Rustler and Saylor, Middlestone, and Stone, dolomite, and dissolution residue of the Rustler Formation; and 134 feet of halite, dissolution residue, and other rocks of the Saylor Formation. The dissolution residue consists of the Rustler contact sand, silt, and gypsum in zones which have commonly returned halite that has been dissolved out of the formation. The dissolution residue of the Saylor Formation consists of sand, silt, gypsum, and remnants of polyhalite beds common in the upper portion of the formation (Jones, 1973).

The thickness of the Rustler Formation from the base of the Corebra Member to the base of the formation in WIPP 29 represents the insoluble residue of about 150 feet of halite and associated rocks that were formerly present (as measured at center of WIPP site). The 105 feet of the Saylor Formation from the top of the formation to the top of the Saylor Rustle Sandstone Member (Adams, 1944) represents the insoluble residue of about 500 feet of halite and associated rocks that were formerly present (as measured at the center of WIPP site). Detailed descriptions of stratigraphic units are provided on Figure 2 and in Table 3.





1. 2014年12月31日，本公司应收账款账面余额为1,000,000.00元，坏账准备余额为0元，计提比例为0%。

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序号	应收账款账面余额	坏账准备	计提比例	计提方法	计提依据	计提金额
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2	1,000,000.00	0.00	0%	账龄分析法	账龄在1-2年	0.00
3	1,000,000.00	0.00	0%	账龄分析法	账龄在2-3年	0.00
4	1,000,000.00	0.00	0%	账龄分析法	账龄在3-4年	0.00
5	1,000,000.00	0.00	0%	账龄分析法	账龄在4-5年	0.00
6	1,000,000.00	0.00	0%	账龄分析法	账龄在5年以上	0.00
7	1,000,000.00	0.00	0%	账龄分析法	账龄在1年以内	0.00
8	1,000,000.00	0.00	0%	账龄分析法	账龄在1-2年	0.00
9	1,000,000.00	0.00	0%	账龄分析法	账龄在2-3年	0.00
10	1,000,000.00	0.00	0%	账龄分析法	账龄在3-4年	0.00
11	1,000,000.00	0.00	0%	账龄分析法	账龄在4-5年	0.00
12	1,000,000.00	0.00	0%	账龄分析法	账龄在5年以上	0.00
13	1,000,000.00	0.00	0%	账龄分析法	账龄在1年以内	0.00
14	1,000,000.00	0.00	0%	账龄分析法	账龄在1-2年	0.00
15	1,000,000.00	0.00	0%	账龄分析法	账龄在2-3年	0.00
16	1,000,000.00	0.00	0%	账龄分析法	账龄在3-4年	0.00
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20	1,000,000.00	0.00	0%	账龄分析法	账龄在1-2年	0.00
21	1,000,000.00	0.00	0%	账龄分析法	账龄在2-3年	0.00
22	1,000,000.00	0.00	0%	账龄分析法	账龄在3-4年	0.00
23	1,000,000.00	0.00	0%	账龄分析法	账龄在4-5年	0.00
24	1,000,000.00	0.00	0%	账龄分析法	账龄在5年以上	0.00
25	1,000,000.00	0.00	0%	账龄分析法	账龄在1年以内	0.00
26	1,000,000.00	0.00	0%	账龄分析法	账龄在1-2年	0.00
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30	1,000,000.00	0.00	0%	账龄分析法	账龄在5年以上	0.00

Table 10. Age-Adjusted Mortality of Sorensen WIPP-29 (continued)

1	10-14	10	1,000	100	2.1	1.1	100.0
2	15-19	10	1,000	100	2.1	1.1	100.0
3	20-24	10	1,000	100	2.1	1.1	100.0
4	25-29	10	1,000	100	2.1	1.1	100.0
5	30-34	10	1,000	100	2.1	1.1	100.0
6	35-39	10	1,000	100	2.1	1.1	100.0
7	40-44	10	1,000	100	2.1	1.1	100.0
8	45-49	10	1,000	100	2.1	1.1	100.0
9	50-54	10	1,000	100	2.1	1.1	100.0
10	55-59	10	1,000	100	2.1	1.1	100.0
11	60-64	10	1,000	100	2.1	1.1	100.0
12	65-69	10	1,000	100	2.1	1.1	100.0
13	70-74	10	1,000	100	2.1	1.1	100.0
14	75-79	10	1,000	100	2.1	1.1	100.0
15	80-84	10	1,000	100	2.1	1.1	100.0
16	85-89	10	1,000	100	2.1	1.1	100.0
17	90-94	10	1,000	100	2.1	1.1	100.0
18	95-99	10	1,000	100	2.1	1.1	100.0
19	100-104	10	1,000	100	2.1	1.1	100.0
20	105-109	10	1,000	100	2.1	1.1	100.0
21	110-114	10	1,000	100	2.1	1.1	100.0
22	115-119	10	1,000	100	2.1	1.1	100.0
23	120-124	10	1,000	100	2.1	1.1	100.0
24	125-129	10	1,000	100	2.1	1.1	100.0
25	130-134	10	1,000	100	2.1	1.1	100.0
26	135-139	10	1,000	100	2.1	1.1	100.0
27	140-144	10	1,000	100	2.1	1.1	100.0
28	145-149	10	1,000	100	2.1	1.1	100.0
29	150-154	10	1,000	100	2.1	1.1	100.0
30	155-159	10	1,000	100	2.1	1.1	100.0
31	160-164	10	1,000	100	2.1	1.1	100.0
32	165-169	10	1,000	100	2.1	1.1	100.0
33	170-174	10	1,000	100	2.1	1.1	100.0
34	175-179	10	1,000	100	2.1	1.1	100.0
35	180-184	10	1,000	100	2.1	1.1	100.0
36	185-189	10	1,000	100	2.1	1.1	100.0
37	190-194	10	1,000	100	2.1	1.1	100.0
38	195-199	10	1,000	100	2.1	1.1	100.0
39	200-204	10	1,000	100	2.1	1.1	100.0
40	205-209	10	1,000	100	2.1	1.1	100.0
41	210-214	10	1,000	100	2.1	1.1	100.0
42	215-219	10	1,000	100	2.1	1.1	100.0
43	220-224	10	1,000	100	2.1	1.1	100.0
44	225-229	10	1,000	100	2.1	1.1	100.0
45	230-234	10	1,000	100	2.1	1.1	100.0
46	235-239	10	1,000	100	2.1	1.1	100.0
47	240-244	10	1,000	100	2.1	1.1	100.0
48	245-249	10	1,000	100	2.1	1.1	100.0
49	250-254	10	1,000	100	2.1	1.1	100.0
50	255-259	10	1,000	100	2.1	1.1	100.0
51	260-264	10	1,000	100	2.1	1.1	100.0
52	265-269	10	1,000	100	2.1	1.1	100.0
53	270-274	10	1,000	100	2.1	1.1	100.0
54	275-279	10	1,000	100	2.1	1.1	100.0
55	280-284	10	1,000	100	2.1	1.1	100.0
56	285-289	10	1,000	100	2.1	1.1	100.0
57	290-294	10	1,000	100	2.1	1.1	100.0
58	295-299	10	1,000	100	2.1	1.1	100.0
59	300-304	10	1,000	100	2.1	1.1	100.0
60	305-309	10	1,000	100	2.1	1.1	100.0
61	310-314	10	1,000	100	2.1	1.1	100.0
62	315-319	10	1,000	100	2.1	1.1	100.0
63	320-324	10	1,000	100	2.1	1.1	100.0
64	325-329	10	1,000	100	2.1	1.1	100.0
65	330-334	10	1,000	100	2.1	1.1	100.0
66	335-339	10	1,000	100	2.1	1.1	100.0
67	340-344	10	1,000	100	2.1	1.1	100.0
68	345-349	10	1,000	100	2.1	1.1	100.0
69	350-354	10	1,000	100	2.1	1.1	100.0
70	355-359	10	1,000	100	2.1	1.1	100.0
71	360-364	10	1,000	100	2.1	1.1	100.0
72	365-369	10	1,000	100	2.1	1.1	100.0
73	370-374	10	1,000	100	2.1	1.1	100.0
74	375-379	10	1,000	100	2.1	1.1	100.0
75	380-384	10	1,000	100	2.1	1.1	100.0
76	385-389	10	1,000	100	2.1	1.1	100.0
77	390-394	10	1,000	100	2.1	1.1	100.0
78	395-399	10	1,000	100	2.1	1.1	100.0
79	400-404	10	1,000	100	2.1	1.1	100.0
80	405-409	10	1,000	100	2.1	1.1	100.0
81	410-414	10	1,000	100	2.1	1.1	100.0
82	415-419	10	1,000	100	2.1	1.1	100.0
83	420-424	10	1,000	100	2.1	1.1	100.0
84	425-429	10	1,000	100	2.1	1.1	100.0
85	430-434	10	1,000	100	2.1	1.1	100.0
86	435-439	10	1,000	100	2.1	1.1	100.0
87	440-444	10	1,000	100	2.1	1.1	100.0
88	445-449	10	1,000	100	2.1	1.1	100.0
89	450-454	10	1,000	100	2.1	1.1	100.0
90	455-459	10	1,000	100	2.1	1.1	100.0
91	460-464	10	1,000	100	2.1	1.1	100.0
92	465-469	10	1,000	100	2.1	1.1	100.0
93	470-474	10	1,000	100	2.1	1.1	100.0
94	475-479	10	1,000	100	2.1	1.1	100.0
95	480-484	10	1,000	100	2.1	1.1	100.0
96	485-489	10	1,000	100	2.1	1.1	100.0
97	490-494	10	1,000	100	2.1	1.1	100.0
98	495-499	10	1,000	100	2.1	1.1	100.0
99	500-504	10	1,000	100	2.1	1.1	100.0
100	505-509	10	1,000	100	2.1	1.1	100.0
101	510-514	10	1,000	100	2.1	1.1	100.0
102	515-519	10	1,000	100	2.1	1.1	100.0
103	520-524	10	1,000	100	2.1	1.1	100.0
104	525-529	10	1,000	100	2.1	1.1	100.0
105	530-534	10	1,000	100	2.1	1.1	100.0
106	535-539	10	1,000	100	2.1	1.1	100.0
107	540-544	10	1,000	100	2.1	1.1	100.0
108	545-549	10	1,000	100	2.1	1.1	100.0
109	550-554	10	1,000	100	2.1	1.1	100.0
110	555-559	10	1,000	100	2.1	1.1	100.0
111	560-564	10	1,000	100	2.1	1.1	100.0
112	565-569	10	1,000	100	2.1	1.1	100.0
113	570-574	10	1,000	100	2.1	1.1	100.0
114	575-579	10	1,000	100	2.1	1.1	100.0
115	580-584	10	1,000	100	2.1	1.1	100.0
116	585-589	10	1,000	100	2.1	1.1	100.0
117	590-594	10	1,000	100	2.1	1.1	100.0
118	595-599	10	1,000	100	2.1	1.1	100.0
119	600-604	10	1,000	100	2.1	1.1	100.0
120	605-609	10	1,000	100	2.1	1.1	100.0
121	610-614	10	1,000	100	2.1	1.1	100.0
122	615-619	10	1,000	100	2.1	1.1	100.0
123	620-624	10	1,000	100	2.1	1.1	100.0
124	625-629	10	1,000	100	2.1	1.1	100.0
125	630-634	10	1,000	100	2.1	1.1	100.0
126	635-639	10	1,000	100	2.1	1.1	100.0
127	640-644	10	1,000	100	2.1	1.1	100.0
128	645-649	10	1,000	100	2.1	1.1	100.0
129	650-654	10	1,000	100	2.1	1.1	100.0
130	655-659	10	1,000	100	2.1	1.1	100.0
131	660-664	10	1,000	100	2.1	1.1	100.0
132	665-669	10	1,000	100	2.1	1.1	100.0
133	670-674	10	1,000	100	2.1	1.1	100.0
134	675-679	10	1,000	100	2.1	1.1	100.0
135	680-684	10	1,000	100	2.1	1.1	100.0
136	685-689	10	1,000	100	2.1	1.1	100.0
137	690-694	10	1,000	100	2.1	1.1	100.0
138	695-699	10	1,000	100	2.1	1.1	100.0
139	700-704	10	1,000	100	2.1	1.1	100.0
140	705-709	10	1,000	100	2.1	1.1	100.0
141	710-714	10	1,000	100	2.1	1.1	100.0
142	715-719	10	1,000	100	2.1	1.1	100.0
143	720-724	10	1,000	100	2.1	1.1	100.0
144	725-729	10	1,000	100	2.1	1.1	100.0
145	730-734	10	1,000				

Geological Survey of Maryland

Rock unit	Depth interval - feet
Unconsolidated deposits	0-12
Chalk	12-59
Chalky dolomite Member	59-82
Chalky sandstone	82-147 (total depth)
Blue Member	147-151
Consolidated residue	151-169
MB 169	169
MB 170	170
MB 171	171
MB 179	179
White dolomite zone	246-277 (total depth)
Consolidated residue	246-261
White Limestone Sandstone Member	261-277
MB 117	277-319
MB 118	319-364
Maximum depth recorded	364

Depth interval recorded from compensated density log included artificial fill for drill pass.

MB, marker bed.

Base of rock unit.

Dr. Adams, 1943.

Table 3. Lithologic log for borehole WHP-29--continued

Lithologic description	Depth Feet
gray (5R 4/2), and light-olive-gray (5Y 5/2), firm but pliable; few small, rounded translucent gypsum crystals less than 0.5 mm	43.0-43.7
gray (5R 4/2), firm, irregular, distorted selenite	43.5-44.0
gray (5R 4/2) to olive-gray (5Y 5/2) clay matrix, firm	44.0-46.4
gray (5R 4/2) to grayish-red (10R 4/2) to dark-gray (5R 4/2) clay matrix	46.4-48.0
gray (5R 4/2) to gray (5Y 5/2), very fine to fine crystallized numerous small, clear, rounded, dotted appearance, containing small, dark, silt matrix, a selenite with appearance, many olive-gray (5Y 5/2) to olive-gray (5Y 6/2) fine shaly wavy laminae, some grayish-red to orange (10R 6/2), and illiteous, zone of randomly dispersed selenite crystals at 55.0-55.4 feet, firm or less to soft irregular	46.4-48.0
gray (5Y 6/1) dolomite hard at 56 feet, very fine crystalline, upper contact 30° from horizontal	46.4-48.0
gray, dark reddish-brown (10R 3/4) to grayish-red (10R 4/2), firm, slightly	50.0-63.0
gray, some light olive-gray (5Y 6/1) siltstone, irregular laminae and	50.0-63.0
gray, firm, silty, zone white gypsum sand (N9) 3/4" thick at 60.7 feet, firm horizontal	50.0-63.0
gray, same as unit at 48.0-63.0 feet, zone white gypsum sand at 64.8 feet,	50.0-63.0
gray, same as unit at 48.0-63.0 feet, zone white gypsum sand at 64.8 feet,	50.0-63.0
gray, same as unit at 63.5-65.4 feet, with many irregular bands and blebs of	63.5-65.4
gray (5Y 6/1) siltstone, zones approximately 3 cm thick of	63.5-65.4
very white (N9) gypsum bands at 71.1 and 73.0 feet, alternating with	63.5-65.4
gray (5Y 6/1) silt, hard olive-gray (5Y 4/2) siltstone, thin	63.5-65.4
thick at 73.3 feet, faintly banded with very thin wavy dark-gray (5R 3/4)	63.5-65.4
gray (N9) gypsum band 2 mm thick at 75.8 feet, 5" dia, with	63.5-65.4
gray (N9) gypsum band 2 mm diameter	67.0-76.6
gray, same as unit at 67.0-76.6 feet, unit became very soft and pitted at	76.6-77.0
of 4 feet, unit is under gauged	76.6-77.0
gray, same as unit at 77.0-79.3 feet	77.0-79.3
gray, same as unit at 79.3-82.0 feet, very soft with few irregular	79.3-82.0
gray and greenish gray (7) siltstone blebs	82.0-84.2
gray, same as unit at 84.2-87.0 feet	84.2-87.0
gray, same as unit at 87.0-87.8 feet	87.0-87.8

	Depth Interval feet
.....	117.0-117.5
.....	117.5-118.0
.....	118.0-118.5
.....	118.5-119.0
.....	119.0-119.5
.....	119.5-120.0
.....	120.0-120.5
.....	120.5-121.0
.....	121.0-121.5
.....	121.5-122.0
.....	122.0-122.5
.....	122.5-123.0
.....	123.0-123.5
.....	123.5-124.0
.....	124.0-124.5
.....	124.5-125.0
.....	125.0-125.5
.....	125.5-126.0
.....	126.0-126.5
.....	126.5-127.0
.....	127.0-127.5
.....	127.5-128.0
.....	128.0-128.5
.....	128.5-129.0
.....	129.0-129.5
.....	129.5-130.0
.....	130.0-130.5
.....	130.5-131.0
.....	131.0-131.5
.....	131.5-132.0
.....	132.0-132.5
.....	132.5-133.0
.....	133.0-133.5
.....	133.5-134.0
.....	134.0-134.5
.....	134.5-135.0
.....	135.0-135.5
.....	135.5-136.0
.....	136.0-136.5
.....	136.5-137.0
.....	137.0-137.5
.....	137.5-138.0
.....	138.0-138.5
.....	138.5-139.0
.....	139.0-139.5
.....	139.5-140.0
.....	140.0-140.5
.....	140.5-141.0
.....	141.0-141.5
.....	141.5-142.0
.....	142.0-142.5
.....	142.5-143.0
.....	143.0-143.5
.....	143.5-144.0
.....	144.0-144.5
.....	144.5-145.0
.....	145.0-145.5
.....	145.5-146.0
.....	146.0-146.5
.....	146.5-147.0
.....	147.0-147.5
.....	147.5-148.0
.....	148.0-148.5
.....	148.5-149.0
.....	149.0-149.5
.....	149.5-150.0

UNIT 151 for borehole 076-29-Continued

Lithologic description	Feet - Interval Feet
Moderate reddish-brown (10R 5/4), to moderate-reddish-brown (10R 4/6), fine to very fine crystalline, same as above; two thin, wavy, white gypsum bands, horizontal at 101.1 and 103.2 feet (10R 6/6), white to gray (10Y 4/1), to olive-gray (5Y 4/1), very fine to fine crystalline, slightly wavy, gradational, very fine, wavy, moderately cement with mud up to, dips 45°-- 50° up.	150.0-151.6 151.6-154.6 154.6-159.7
Laminated, white to light gray (10B 6/6), gypsum bands, 30 (10R 4/6) and 30 (10R 4/6) feet horizontal, to (10R 4/6), wavy, moderate to very fine crystalline,	159.7-164.4 164.4-169.9 169.9-175.6
(10R 4/6), wavy, unit 159.7-164.4 feet, grading to (10R 4/6), to olive-gray (5Y 4/1), to light olive-gray (4Y 4/1), and moderate-reddish-brown (10R 4/6), very fine to fine crystalline, argillaceous, slightly wavy laminae of contrasting colors above, continuous, slightly dispersed, all generally trending 53° from horizontal, mod. to medium gray (10B 6/6), clay hard, 1-3 mm, to 1/2-1/4 feet.	168.0-172.4 172.4-179.9
Sandstone, moderate-reddish-brown (10R 4/6), hard to very hard, with numerous clasts, light gray to gray (10B 7/1), sandstone, 1/2 to 1/4 diameter, calcite veins, 1/2 mm thick at 172.7 feet, 3/4 from horizontal.	172.4-173.7
(10R 4/6), fine to medium brown (10R 4/6) to moderate reddish-brown (10R 4/6), soft, firm, granular, nodules of white (10B 6/6) gypsum, colorless, cherty, to 1/2 mm, nodules 1/2-1/4 feet.	174.0-176.4 176.4-177.7
(10R 4/6), to olive-gray (5Y 4/1), with numerous fragments of gypsum, to olive-gray (5Y 4/1) to olive-gray (4Y 4/1), moderate-reddish- brown (10R 4/6) and moderate-reddish-brown (10R 4/6), and moderate- reddish-brown (10R 6/6), colorless, chalky, very fine to fine crystalline, fine to 3/4 mm, subangular to subrounded, moderate- reddish-brown (10R 4/5) clay, soft, firm, moderate-reddish-brown (10R 4/6), siltstone, moderately hard, two gypsum bands, 1.5-4 cm thick at 178.3 and 179.1 feet; gypsum thick, with slightly wavy gypsum veinlets, off white to white (10B 6/6), 1-2 mm thick at 178.4-179.3 feet, 0.5 from horizontal; mod w-gray (10B 6/6) clay bands, 1/2 to 1 mm thick, 0.5 from horizontal at 179.3 feet.	176.4-180.1

Table 3.--Lithologic log for borehole WIPP-29--Continued.

Lithologic description	Depth Interval feet
Clay, moderate-reddish-brown, less than 1 mm thick, few fractures present; fragments altered to white (N9), gypsum, some filled with moderate-reddish-brown (1OR 4/6), clay-----	21.0
Clay, same as unit 180.0-180.7 feet; laminae dipping 10-15° at 180.0-180.5 feet; fracture 0.1 ft from horizontal, displacement 1 mm, filled with moderate-reddish-brown (1OR 4/6) clay, at 180.4 feet; numerous fragments of light-olive-gray (5Y 6/1)	180.0-180.7
Siltstone, 2 mm to 2 cm in size, subrounded at 197.0-206.7 feet----- Siltstone, light-olive-gray (5Y 6/1), hard, small scale cross-bedding, slightly dolomitic; contacts 0.9 ft from horizontal----- Gypsum in a clay matrix; gypsum fragments, light-olive-gray (5Y 6/1) to olive-black (5Y 2/1), white (N9), some moderate-reddish-brown (1OR 4/6), 1-5 mm in size, subrounded to rounded, within a moderate-brown (5YR 3/4) to grayish-red (1OR 4/2), clay matrix, firm, soft-----	197.0-206.7
Clay, moderate-reddish-brown (1OR 4/6), soft, firm, friable; with fragments of white (N9) to colorless, light-olive-gray (5Y 6/1), gypsum, rounded to subrounded, 2-6 mm in size; possible altered fragments of moderate-reddish-orange (1OR 6/6) to orange polyhalite, 2 mm to 1 cm, rounded-----	224.0-225.3
Gypsum, light-olive-gray (5Y 6/1) to olive-gray (5Y 4/1), colorless, some olive-black (5Y 2/1), very fine crystalline, mottled, numerous, irregular, wavy, laminae, 1-2 mm thick of contrasting colors; two zones 18.3 and 9.2 cm thick, respectively, of possibly altered moderate-reddish-orange (1OR 6/6) to moderate-reddish-brown (1OR 4/6) halite polyhalite at 224.0 and 225.3 feet-----	224.0-225.3
Gypsum in a clay matrix, same as unit 197.0-206.7 feet; block of pale-reddish-orange (1OR 6/6), white (N9) gypsum, very fine crystalline, argillaceous at 232.8-234.0 feet; discontinuous band of altered polyhalite, 18.3 cm thick at 236.0 feet-----	232.8-234.0
Gypsum, moderate-orange-pink (1OR 7/4), white (N9), some colorless to light-gray (N7); very fine crystalline; faint bands of gypsum, 2-10 cm thick; pits filled with recrystallized gypsum; two zones of recrystallized colorless gypsum, medium-to coarse-crystalline at 240.3 and 241.9 feet-----	240.3-241.9
Clay, dark-reddish-brown (1OR 3/4), soft-----	241.9-242.0
Clay, same as above, with numerous colorless halite crystals----- Halite, colorless, with moderate-reddish-brown (1OR 4/6) tint;	242.0-242.1

Geological description for Stratigraphic Unit 23-51 (cont'd)

Geological description	Depth (feet)
fine-grained, silty, with interstitial dark-red-brown (10R 5/4)	251.0-254.0
fine-grained, silty, with interstitial dark-red-brown (10R 5/4)	259.4-260.0
fine-grained, silty, with interstitial dark-red-brown (10R 5/4)	261.0-262.0
fine-grained, silty, with interstitial dark-red-brown (10R 5/4), medium to coarse-grained, silty, with interstitial dark-red-brown (10R 5/4), medium to coarse-grained, silty, with interstitial dark-red-brown (10R 5/4), polyhalite bands, 5-10 cm thick, irregularly shaped, 10R 5/4	265.0-270.0
fine-grained, silty, with interstitial dark-red-brown (10R 5/4), polyhalite bands, 1-2 cm thick, irregularly shaped, 10R 5/4	270.0-271.0
fine-grained, silty, with interstitial dark-red-brown (10R 5/4)	271.0-272.0
fine-grained, silty, with interstitial dark-red-brown (10R 5/4), polyhalite bands, 1-2 cm thick, irregularly shaped, 10R 5/4, polyhalite bands, 1-2 cm thick, irregularly shaped, 10R 5/4, polyhalite bands, 1-2 cm thick, irregularly shaped, 10R 5/4, polyhalite bands, 1-2 cm thick, irregularly shaped, 10R 5/4, polyhalite bands, 1-2 cm thick, irregularly shaped, 10R 5/4	288.0-291.0
fine-grained, silty, with interstitial dark-red-brown (10R 5/4)	291.5-292.0
fine-grained, silty, with interstitial dark-red-brown (10R 5/4), polyhalite bands, 1-2 cm thick, irregularly shaped, 10R 5/4, polyhalite bands, 1-2 cm thick, irregularly shaped, 10R 5/4, polyhalite bands, 1-2 cm thick, irregularly shaped, 10R 5/4, polyhalite bands, 1-2 cm thick, irregularly shaped, 10R 5/4, polyhalite bands, 1-2 cm thick, irregularly shaped, 10R 5/4	292.0-293.0
fine-grained, silty, with interstitial dark-red-brown (10R 5/4), polyhalite bands, 1-2 cm thick, irregularly shaped, 10R 5/4, polyhalite bands, 1-2 cm thick, irregularly shaped, 10R 5/4, polyhalite bands, 1-2 cm thick, irregularly shaped, 10R 5/4, polyhalite bands, 1-2 cm thick, irregularly shaped, 10R 5/4, polyhalite bands, 1-2 cm thick, irregularly shaped, 10R 5/4	296.0-297.0
fine-grained, silty, with interstitial dark-red-brown (10R 5/4)	304.0-305.0
fine-grained, silty, with interstitial dark-red-brown (10R 5/4) and pale-red (10R 7/4)	310.0-311.0
fine-grained, silty, with interstitial dark-red-brown (10R 5/4) and pale-red (10R 7/4)	314.0-316.0
fine-grained, silty, with interstitial dark-red-brown (10R 5/4) and pale-red (10R 7/4), polyhalite bands, 1-2 cm thick, irregularly shaped, 10R 5/4, polyhalite bands, 1-2 cm thick, irregularly shaped, 10R 5/4, polyhalite bands, 1-2 cm thick, irregularly shaped, 10R 5/4, polyhalite bands, 1-2 cm thick, irregularly shaped, 10R 5/4, polyhalite bands, 1-2 cm thick, irregularly shaped, 10R 5/4	316.0-318.0

Section 22, Twp. 16N., R. 10E., A196-29--Continued

Lithology	Depth Interval Feet
100-105 feet: 100-101 feet, 101-102 feet, 102-103 feet, 103-104 feet, 104-105 feet 105-110 feet: 105-106 feet, 106-107 feet, 107-108 feet, 108-109 feet, 109-110 feet 110-115 feet: 110-111 feet, 111-112 feet, 112-113 feet, 113-114 feet, 114-115 feet 115-120 feet: 115-116 feet, 116-117 feet, 117-118 feet, 118-119 feet, 119-120 feet 120-125 feet: 120-121 feet, 121-122 feet, 122-123 feet, 123-124 feet, 124-125 feet 125-130 feet: 125-126 feet, 126-127 feet, 127-128 feet, 128-129 feet, 129-130 feet 130-135 feet: 130-131 feet, 131-132 feet, 132-133 feet, 133-134 feet, 134-135 feet 135-140 feet: 135-136 feet, 136-137 feet, 137-138 feet, 138-139 feet, 139-140 feet 140-145 feet: 140-141 feet, 141-142 feet, 142-143 feet, 143-144 feet, 144-145 feet 145-150 feet: 145-146 feet, 146-147 feet, 147-148 feet, 148-149 feet, 149-150 feet 150-155 feet: 150-151 feet, 151-152 feet, 152-153 feet, 153-154 feet, 154-155 feet 155-160 feet: 155-156 feet, 156-157 feet, 157-158 feet, 158-159 feet, 159-160 feet 160-165 feet: 160-161 feet, 161-162 feet, 162-163 feet, 163-164 feet, 164-165 feet 165-170 feet: 165-166 feet, 166-167 feet, 167-168 feet, 168-169 feet, 169-170 feet 170-175 feet: 170-171 feet, 171-172 feet, 172-173 feet, 173-174 feet, 174-175 feet 175-180 feet: 175-176 feet, 176-177 feet, 177-178 feet, 178-179 feet, 179-180 feet 180-185 feet: 180-181 feet, 181-182 feet, 182-183 feet, 183-184 feet, 184-185 feet 185-190 feet: 185-186 feet, 186-187 feet, 187-188 feet, 188-189 feet, 189-190 feet 190-195 feet: 190-191 feet, 191-192 feet, 192-193 feet, 193-194 feet, 194-195 feet 195-200 feet: 195-196 feet, 196-197 feet, 197-198 feet, 198-199 feet, 199-200 feet 200-205 feet: 200-201 feet, 201-202 feet, 202-203 feet, 203-204 feet, 204-205 feet 205-210 feet: 205-206 feet, 206-207 feet, 207-208 feet, 208-209 feet, 209-210 feet 210-215 feet: 210-211 feet, 211-212 feet, 212-213 feet, 213-214 feet, 214-215 feet 215-220 feet: 215-216 feet, 216-217 feet, 217-218 feet, 218-219 feet, 219-220 feet 220-225 feet: 220-221 feet, 221-222 feet, 222-223 feet, 223-224 feet, 224-225 feet 225-230 feet: 225-226 feet, 226-227 feet, 227-228 feet, 228-229 feet, 229-230 feet 230-235 feet: 230-231 feet, 231-232 feet, 232-233 feet, 233-234 feet, 234-235 feet 235-240 feet: 235-236 feet, 236-237 feet, 237-238 feet, 238-239 feet, 239-240 feet 240-245 feet: 240-241 feet, 241-242 feet, 242-243 feet, 243-244 feet, 244-245 feet 245-250 feet: 245-246 feet, 246-247 feet, 247-248 feet, 248-249 feet, 249-250 feet 250-255 feet: 250-251 feet, 251-252 feet, 252-253 feet, 253-254 feet, 254-255 feet 255-260 feet: 255-256 feet, 256-257 feet, 257-258 feet, 258-259 feet, 259-260 feet 260-265 feet: 260-261 feet, 261-262 feet, 262-263 feet, 263-264 feet, 264-265 feet 265-270 feet: 265-266 feet, 266-267 feet, 267-268 feet, 268-269 feet, 269-270 feet 270-275 feet: 270-271 feet, 271-272 feet, 272-273 feet, 273-274 feet, 274-275 feet 275-280 feet: 275-276 feet, 276-277 feet, 277-278 feet, 278-279 feet, 279-280 feet 280-285 feet: 280-281 feet, 281-282 feet, 282-283 feet, 283-284 feet, 284-285 feet 285-290 feet: 285-286 feet, 286-287 feet, 287-288 feet, 288-289 feet, 289-290 feet 290-295 feet: 290-291 feet, 291-292 feet, 292-293 feet, 293-294 feet, 294-295 feet 295-300 feet: 295-296 feet, 296-297 feet, 297-298 feet, 298-299 feet, 299-300 feet 300-305 feet: 300-301 feet, 301-302 feet, 302-303 feet, 303-304 feet, 304-305 feet 305-310 feet: 305-306 feet, 306-307 feet, 307-308 feet, 308-309 feet, 309-310 feet 310-315 feet: 310-311 feet, 311-312 feet, 312-313 feet, 313-314 feet, 314-315 feet 315-320 feet: 315-316 feet, 316-317 feet, 317-318 feet, 318-319 feet, 319-320 feet 320-325 feet: 320-321 feet, 321-322 feet, 322-323 feet, 323-324 feet, 324-325 feet 325-330 feet: 325-326 feet, 326-327 feet, 327-328 feet, 328-329 feet, 329-330 feet 330-335 feet: 330-331 feet, 331-332 feet, 332-333 feet, 333-334 feet, 334-335 feet 335-340 feet: 335-336 feet, 336-337 feet, 337-338 feet, 338-339 feet, 339-340 feet 340-345 feet: 340-341 feet, 341-342 feet, 342-343 feet, 343-344 feet, 344-345 feet 345-350 feet: 345-346 feet, 346-347 feet, 347-348 feet, 348-349 feet, 349-350 feet 350-355 feet: 350-351 feet, 351-352 feet, 352-353 feet, 353-354 feet, 354-355 feet 355-360 feet: 355-356 feet, 356-357 feet, 357-358 feet, 358-359 feet, 359-360 feet 360-365 feet: 360-361 feet, 361-362 feet, 362-363 feet, 363-364 feet, 364-365 feet 365-370 feet: 365-366 feet, 366-367 feet, 367-368 feet, 368-369 feet, 369-370 feet 370-375 feet: 370-371 feet, 371-372 feet, 372-373 feet, 373-374 feet, 374-375 feet 375-380 feet: 375-376 feet, 376-377 feet, 377-378 feet, 378-379 feet, 379-380 feet 380-385 feet: 380-381 feet, 381-382 feet, 382-383 feet, 383-384 feet, 384-385 feet 385-390 feet: 385-386 feet, 386-387 feet, 387-388 feet, 388-389 feet, 389-390 feet 390-395 feet: 390-391 feet, 391-392 feet, 392-393 feet, 393-394 feet, 394-395 feet 395-400 feet: 395-396 feet, 396-397 feet, 397-398 feet, 398-399 feet, 399-400 feet 400-405 feet: 400-401 feet, 401-402 feet, 402-403 feet, 403-404 feet, 404-405 feet 405-410 feet: 405-406 feet, 406-407 feet, 407-408 feet, 408-409 feet, 409-410 feet 410-415 feet: 410-411 feet, 411-412 feet, 412-413 feet, 413-414 feet, 414-415 feet 415-420 feet: 415-416 feet, 416-417 feet, 417-418 feet, 418-419 feet, 419-420 feet 420-425 feet: 420-421 feet, 421-422 feet, 422-423 feet, 423-424 feet, 424-425 feet 425-430 feet: 425-426 feet, 426-427 feet, 427-428 feet, 428-429 feet, 429-430 feet 430-435 feet: 430-431 feet, 431-432 feet, 432-433 feet, 433-434 feet, 434-435 feet 435-440 feet: 435-436 feet, 436-437 feet, 437-438 feet, 438-439 feet, 439-440 feet 440-445 feet: 440-441 feet, 441-442 feet, 442-443 feet, 443-444 feet, 444-445 feet 445-450 feet: 445-446 feet, 446-447 feet, 447-448 feet, 448-449 feet, 449-450 feet 450-455 feet: 450-451 feet, 451-452 feet, 452-453 feet, 453-454 feet, 454-455 feet 455-460 feet: 455-456 feet, 456-457 feet, 457-458 feet, 458-459 feet, 459-460 feet 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to the hole. The hole was drilled in the field site using a 100 ft. long, 4.5 inch diameter, 1000 lb. draw drill. The survey for the draw drill hole (both horizontally and vertically), the drilling depths as furnished by the drillers, and the wireline log measurements by the 1999-2000 campaign. Wellbore location and depths to the borehole are shown in this report in English units. If metric units are desired, the following conversion factors should be used:

Multiply English unit	By	To Obtain Metric Unit
feet (ft)	0.3048	meters (m)
inches (in)	2.54	centimeters (cm)
pounds per square foot	0.06895	kilopascals (kPa)

4.0. GEOLOGICAL DATA

4.1. Geological Data were obtained from the data log in Table 1.

5.0. REMARKS

The first objective of the Sand Draw drilling program, to determine the stratigraphic sequence of the formation, has partially fulfilled. This report now provides the stratigraphic data for the top of the Salado Formation, and a few marker beds within the upper Salado, at WHP 29.

The second objective, to examine the relationship between subsurface structure and potential to ores, and depth, will be fulfilled through the integrated interpretation of the Sand Draw geologic and hydrologic data in this and other reports.

The third objective, to investigate the dissolution of the ore rocks by groundwater, will be met through field hydrology tests and laboratory examination of dissolution products to determine, as possible, ionic and gaseous. The hydrological programs have not yet been initiated; laboratory programs are still being initiated.

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APPENDIX A

JUSTIFICATION

by

S. J. Lambert
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INTRODUCTION TO APPENDIX A, JUSTIFICATION

Appendix A consists of relevant portions of two related documents:

- 1) memorandum from S. J. Lambert to Distribution, dated 6/8/78, "WIPP Programs to Investigate the Natural and Effects of Salt Dissolution and Overburden Salt Debris in the Vicinity of the WIPP site," and
- 2) memorandum from S. J. Lambert to R. D. Statler, dated 6/29/78, "Criteria for WIPP 29 Through WIPP 30 and Final Quality Assurance."

These documents provide details of background information and program options as understood at the time of initiation. The report is cautioned, therefore, that details of the program may have been modified as information became available and that preliminary interpretations, hypotheses or ideas guiding the program formulation may need to be modified based on information presented in this report. Later interim reports may deal with such items.

June 8, 1978

Distribution

Steven J. Lambert

S. J. Lambert - 5311

WIPP Programs to Investigate the Nature and Effects of Salt Dissolution and Overburden Subsidence in the Vicinity of the WIPP Site

Definitions of Problems

Bedded deposits of Permian rock salt of the Gonian epoch in southeastern New Mexico's portion of the Delaware Basin are not found near the surface because of halite's appreciable solubility. These deposits are preserved at depth where the overburden rocks' permeability is low enough to preclude the exposure of rock salt to significant amounts of circulating solutions which are not saturated with sodium chloride. When the overburden barrier is somehow breached, fluids may more easily reach the salt. The salt dissolves, is removed, and the overburden collapses into the void space left as a result of salt removal. Commonly this collapse is expressed at the surface as a set of features such as sinkholes, and a karst topography reminiscent of limestone terrain develops. Since the most prevalent soluble rocks of the Delaware Basin are halite and anhydrite, not limestone, the relationship between salt dissolution and subsequent development of karst-like surface features is not altogether well defined. Whereas limestone is but sparingly soluble in meteorically-derived water, and spectacular sinkholes may be observed at the surface in some localities, sinkholes which might develop in salt at depth are obscured by the overburden, which has since collapsed into commonly chaotic rubble, particularly near the surface. In addition, limestone has greater mechanical strength than rock salt, and has greater potential of maintaining an open sinkhole than salt, which has a tendency to self-seal under overburden pressure. Gypsum (formed from the original anhydrite by interaction with near-surface groundwaters) is intermediate in solubility between limestone and rock salt, and might more readily maintain a cavity than would rock salt.

An additional complication encountered in studying karstic features in southeastern New Mexico is the climate. The sparse vegetative cover in semiarid karstic regions leads to minimal soil stabilization; many small scale features indicative of subsurface dissolution of rock and collapse of overburden are filled in with poorly consolidated surface material almost as soon as they are formed. This appears to be the case of surface

fractures associated with subsidence over mines and cataclysmic collapse episodes (such as occurred at San Simon Sink in historic times). These fractures were quickly filled by brine salts.

A primary concern for a radioactive waste repository is brine flow and its long-term integrity of the salt itself. In the case of the WIPP site at Los Medanos, a zone of apparently active dissolution of salt has been identified near the top of the Salado Formation (about 1300 feet or 400 meters above the uppermost horizon proposed for waste emplacement) at the western periphery of the proposed 30-square-mile land withdrawal area. Whereas no small-scale karstic features are developed in this area, and evidence for dissolution in the area is based entirely upon subsurface borehole data, a large depression called Nash Draw is developed to the west of the area. Exploratory drilling for potash in Nash Draw has revealed the removal of halite in the Rustler and Salado Formations and the development of a permeable brine-bearing zone of residue of dissolved evaporites called the "brine aquifer". The brine aquifer was probably encountered in hole P14 on the western margin of the WIPP area, yet the actual topographic edge of Nash Draw is no closer than one mile west of the WIPP land withdrawal area. Thus the development of Nash Draw is shrouded in mystery: what has been the relationship between dissolution of salt and subsidence of workloads in Nash Draw?

What are the implications (regarding WIPP-horizon salt integrity) of fluid movement, dissolution and subsidence involving salt above the WIPP? And how do these implications relate to safety assessment of WIPP through scenarios involving the supra-Salado rocks at the WIPP site and the ability to carry radionuclides in their aquifers into the biosphere? G. Bachman in USGS Open-File report 74-194 (1974) estimated average rates of salt dissolution in this area of about six to eight miles per million years horizontally, and 1/3 foot per thousand years vertically. If these estimates are correct, further evaluation of Nash Draw is unnecessary; it would, however, provide confidence in the earlier estimates.

An additional concern is the region that must be controlled around the WIPP. Currently, DOE prescriptions specify control of a two-mile radius around the possible WIPP workings. Within this zone, various degrees of resource production will be allowed. If the effects of subsidence were understood and of lesser consequences than allowed for today, greater production of potash and hydrocarbons might be acceptable within portions of the two-mile zone.

Special Investigations

The proper investigation of dissolution and subsidence are four fundamental purposes, with one special-case consideration:

1. To correlate surface collapse features and deposits with subsurface dissolution, in order to develop criteria for determining if there is a relationship between surface collapse.
2. To characterize subsurface dissolution products adjacent to the WIPP site.
3. To determine the behavior of fluids in dissolution zones adjacent to the WIPP site.
4. To analyze potential impacts of evolution of dissolution products at and near the WIPP site with respect to potential breaching and radionuclide transport.

The special case is to determine the nature of subsidence associated with salt, and its effects on the overlying groundwater system.

An elaboration of these purposes follows.

Nash Draw Investigations

Nash Draw, the "dog-bone" shaped depression adjacent to the WIPP site, is thought to have originated by some combination of surface erosion and subsidence following subsurface dissolution. If the process of formation is overwhelming dissolution, then the potential for removal of overburden at the WIPP site is probably about the same as it has been in Nash Draw. If, however, the process is overwhelmingly dissolution of salt and collapse of overburden, the potential exists for the development of a complex system of stratigraphic and hydrological relationships near the WIPP, much as what has developed in Nash Draw. At present, there is no conclusive way of defining an instantaneous rate of growth of Nash Draw toward the WIPP site; therefore, the only alternative is to understand the processes which have resulted in Nash Draw, and incorporate their implications into the mathematical modeling efforts directed toward safety assessment involving the WIPP site in general, and radionuclide escape and migration in particular.

First, the Nash Draw program is a series of core holes, which will be geophysically logged. This operation will obtain data to serve three purposes: 1) reveal the subsurface Nash Draw stratigraphy at carefully chosen points, 2) reveal the relationships between the subsurface structure and surface features and deposits, 3) reveal how much halite and anhydrite (or gypsum) has been removed by dissolution. The holes will indeed be

located near surface features which suggest that dissolution has taken place in the subsurface has taken place, so that the present landscape is a surface that has been modified (see #2). Stratigraphy of past-Nash Draw deposits will be used to unravel the history of development of the landscape (see above). Examination for missing constituents will permit a comparison of dissolution rates in the dissolved surface features, and where dissolution has occurred to various degrees (#3). Characterization of surface features found at sites having experienced various degrees of dissolution will allow for the determination of the pattern of dissolution collected, if any. Thus, the objectives of this second data requirements should contain the following program objective #1.

Second, the Nash Draw program is designed to be instrumental for petrographic and geochemical examination. Making thin sections of recovered rock will allow the determination of dissolution products to be determined, and identification of what was dissolved and what remains. Mineralogy and textures of dissolution residues and cemented rubble will then be compared with those of dissolution residues and cemented rubble programs, such as the one to investigate the cemented rubble chimneys (oft called "karstic debris chimneys", informally, "breccia pipes"). Comparisons can be made to see if Nash Draw and cemented rubble chimneys have involved similar processes of formation. Geochemical analysis of rock materials for trace constituents will reveal their source of interaction with groundwaters, and possibly an age of formation. Also, permeabilities toward fluids can be obtained on cores. Thus, the second program objective is satisfied.

Third, the Nash Draw program will develop a series of hydrologic poles. The "brine aquifer" underlying Nash Draw has been attributed responsibility for much of the dissolution and collapse observed today. The same "brine aquifer" has been attributed responsibility for carrying radionuclides should they escape from WIPP to the biosphere, allegedly via the seeps at Malaga. It therefore behooves us to understand the potentiometric patterns, permeability variations, and fluid quantities found in that aquifer. Furthermore, the safety assessment scenarios for radionuclide escape and migration involve movement from WIPP into Rustler Formation waters into the "brine aquifer" and out at Malaga. It also behooves us to understand the hydrologic relationships between the "brine aquifer" and the Rustler water-bearing rocks in Nash Draw. And with this understanding, program objective #3 is satisfied.

For fiscal year 1978, four and possibly five Nash Draw holes have been proposed. It is expected that the program will extend through the fiscal year 1979, with up to nine additional holes, logistic resources permitting. The first six holes are located and identified according to nearest named landmark as follows:

W189-NH-1	S15-T228-R30E	Crawford Basin
W189-NH-2	S25-T218-R30E	Eastyniter Mine
W189-NH-3	S21-T218-R30E	Red Lake
W189-NH-4	S18-T218-R31E	Low Well
W189-NH-5	S15-T228-R30E	Paradise Mine
W189-NH-6	S22-T218-R31E	Hope Tank

Surface casing conductor pipes will be set similar to W189-19. Holes 1, 2 and 4, are to be cored as completely as possible into the upper Dakota formation to an identifiable marker bed. The core size should be 2 1/2" diameter, taken to 20'. Approximate projected TD's for the first four holes are 195, 245-425, 415 and 500-600 ft, respectively. A geologic prognosis of each location will be provided by G. E. Jones, M.D.C., prior to drilling each hole. In addition, resistivity surveying in Nash Draw will precede drilling, if possible. Loss of circulation is anticipated in holes 1, 2 and 3.

Geophysical logs in the holes on 1/2" casing, resistivity, density, gamma, neutron, sidescan, and caliper. The sonic log might not be obtainable if the hole cannot maintain a fluid column long enough, but is desirable. Open-hole velocity to all depths interpretation might be appropriate.

After the drilling (and/or casing) has been completed it is planned to stand 5 1/2" casing and cement it to the surface. Each hole then becomes available for hydrologic testing and monitoring. Each hole will then be subjected to the same sorts of treatment as described in SAND 77-1461. Information so obtained includes piezometric potentials, permeabilities, quantities of fluids and the degree of connectedness between the Rustler rocks and the "arvic aquifer." In addition, water samples will be analyzed to determine their origins and role in dissolution. The cores of water-bearing rocks can be analyzed for porosity and nucleic-sorption affinity. The results can be implemented in modeling efforts for safety assessment, and program objective #4 will have been satisfied.

As well as modeling groundwater movement, it may be advantageous to attempt to model the dissolution that might govern the future development of Nash Draw, once the evolutionary relationships among processes in the cycle: dissolution - collapse - fracturing - water entry - dissolution, are understood.

General Rubble Chimney Investigations

One of the "classic domal features" described in the literature (referred to as Hill "C") was encountered at the low resistivity zone in the ash zone by Mississippi Chemical Corporation. It was thought to be a chimney in the Salado Formation filled with clay cemented brecciated rock belonging to strata above the Salado. Similarly a breccia-filled chimney was encountered in drillings near a circular hill near the Weaver Mine. There are numerous other erosion-breached domes such as Vine's Hill "C" in the vicinity of Nash Draw; the subsurface expression of them, if any, is virtually unknown. Recent geophysical surveys of the region have revealed that many of these domes, including the Weaver and Hill "C", are associated with resistivity lows.

The such resistivity low, without conspicuous surface expression, has been reported in section 17, T22S, R31E, inside the WIPP area. This suggests a localized increase in fluid content or rock and possibly a local porosity high and could be interpreted as a possible fluid-carrying event. Implications of fluid movement in evaporites are, of course, dissolution and collapse. Once the initial resistivity low and the location of the section 17 low is corroborated by a ground survey, WIPP borehole #13 will be drilled to determine the nature of the low. Should the low prove to be a rubble chimney near the surface, a decision point is defined, requiring a careful investigation of the nature and properties of the section 17 feature including a deep exploratory well, WIPP 16, to determine the threat, if any, or 2) temporary abandonment of WIPP #13 while WIPP 16 is drilled in another resistivity low, which might have a breached dome, or even in one of the known suspected rubble chimneys, or 3) site abandonment if the implications regarding threat of such a feature to WIPP safety are never to be understood.

Should a decision be necessary, the most scientifically expedient yet intellectually conservative approach is option #2. Experience in drilling (and perhaps instrumentation development) gained from WIPP 16 in a "known" (or at least strongly suspected) rubble chimney will be welcome when the onsite resistivity low is resisted to investigate it in detail.

A program for WIPP 16 in the case of a "known" chimney should consider the following information requirements:

1. Recovery of core from as many portions of the structure as possible.
2. Recovery of representative analyzeable samples of any liquids encountered.

3. Recovery of representative analyzable samples of any gases encountered.
4. The option to make in situ determinations of permeabilities to liquids and diffusion coefficients for gases.
5. Determination of the reservoir size, if any, of liquid and gases.
6. An adequate description of the physical, chemical and geological properties of the structure as is practically obtainable.

The achievement of these goals will probably require the following considerations:

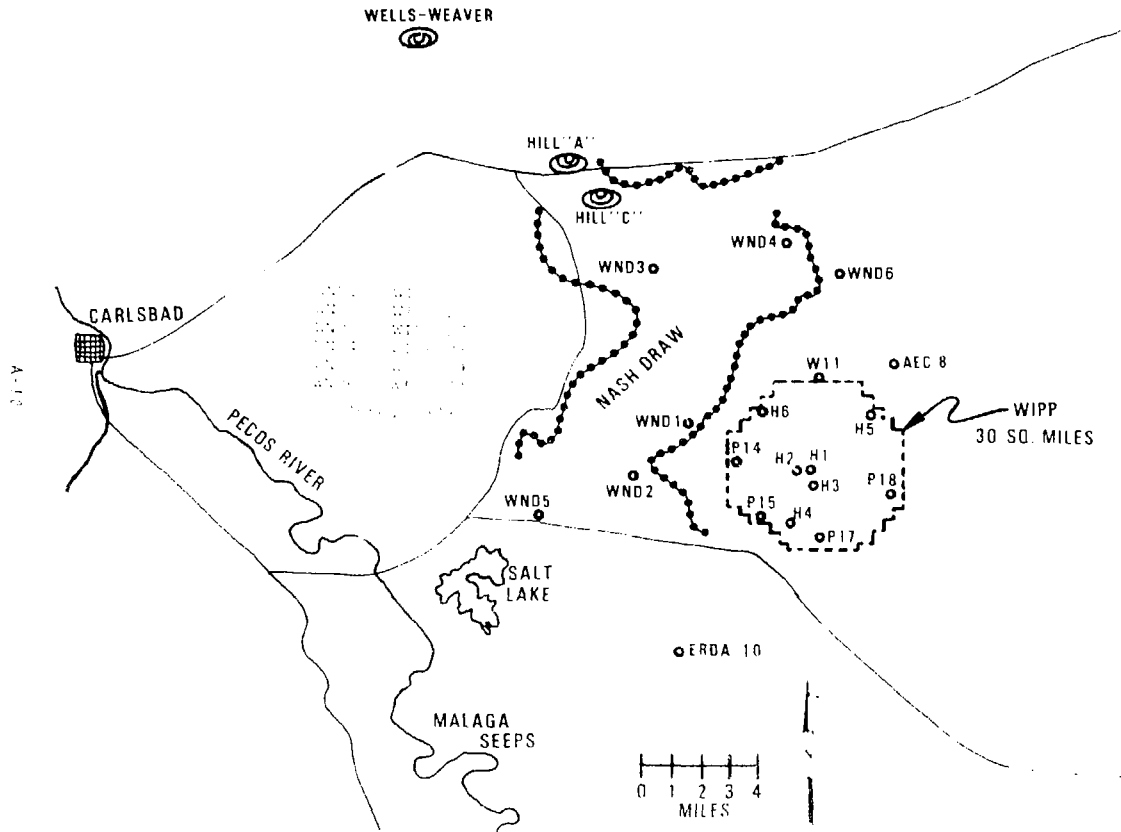
1. Use of a drill rig able to penetrate about 5000 feet of section.
2. Employment of blowout preventers, fluid detection, alarm and collection systems.
3. The option of drilling with air or mud.
4. The ability to take fluid samples by the rotary method from any of the radial or vertical zones.
5. The option of wirestracking of a central (axial) hole to any radial zones.
6. Directional surveys to allow "mapping" the subsurface extent of the structure.
7. The taking of geophysical logs, including resistivity, density, gamma, neutron, sidescan and caliper, some if possible.
8. The option to multiply complete the resulting hole(s) for hydrologic testing.

It is desirable that this hole be drilled to a depth at which no more associated rock is found. Should solid rock be encountered in the reef complex, it is recommended that the hole be cased down to the carbonate for hydrologic observation. Hydrologic observation (including water sampling and piezometry) in fluid-bearing zones of the structure itself and in "bedrock" and in nearby rocks will help to determine the degree of connectedness of the structure with aquifers of regional extent.

Further analytical analyses of core recovered will allow comparisons to be made with dissolution products recovered from North Sea investigations, described previously. Such comparisons will allow itself to geochemical analyses for the determination of water interaction history and age. Similarly, fluid inclusion analysis will provide an indication of how the fluids have interacted with their host rocks, helping to determine the processes at work in such structures. The rock chemistry of the WIPs can also be compared with Hill "2," detailed in Hill et al.

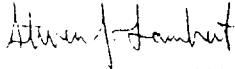
Given the modeling of radiolysis products and the potential to take into account fluid movement, a risk assessment model could be evaluated for the potential hazards of the WIPs. The model should also be evaluated against the irregular, non-cylindrical pattern of dissolution products. The model might be generically related to the development of the WIPs. Consequently, it is desirable to generate a quantitative permeability of the structure. This would allow the opportunity for development of secondary instrumentation to be used in the exploration of the WIPs. In fact, the relationship between the hydrologic relationships between the structure and the rocks should be understood in order to formulate a quantitative hydrologic model for risk assessment. Thus, the following objectives will have been met for the case of the WIPs: (1) the chimneys and these dissolution products can be related to those encountered in the North Sea region.

HYDROLOGY TEST PROGRAM



June 29, 1978

K. D. Stabler, 1133



S. J. Lambert, 5311

Criteria for WIPP 25 Through WIPP 30, and Their Quality Assurance

Reference: S. J. Lambert to Distribution, dtc. 6/8/78, "WIPP Programs to Investigate the Nature and Effects of Salt Dissolution and Overburden Subsidence in the Vicinity of the WIPP Site"

Purposes

The holes WIPP 25 through WIPP 30 are informally known as ND through ND6.

First, these are a series of core holes to be geophysically logged, to serve three purposes: (1) reveal the subsurface Nash Draw stratigraphy at carefully chosen points, (2) reveal the relationships between the subsurface structure and surface features and deposits, (3) reveal how much halite and anhydrite (or gypsum) has been removed by dissolution.

Second, these holes are a source of natural geologic material for petrographic and geochemical examination of products of dissolution of evaporites adjacent to the WIPP area, for studies of age-dating, rock-water interactions and related phenomena.

Third, the Nash Draw holes are to become a series of hydrology holes to provide the modelling (safety assessment) effort with data regarding dissolution and groundwater flow in a geologically complex piece of territory, between the west border of the WIPP area (Livingston Ridge) and the Pecos River, the nearest permanent surface water accessible to humans.

Locations

The lateral location of each hole was selected by the Water Resources Division of the United States Geological Survey. The precise location of each hole is governed by the surface feature it is designed to explore. In general, a lateral

direction to ensure penetration of 1/2 inch. At the end, the core portion of interest should be protected by a 1/2 inch diameter surface impression and, therefore, the hole must fill with it. The portion of interest is the depth of penetration of core to be recovered after completion of operations so as to be known within one foot with respect to vertical location. It is desirable to clearly mark the bottom marker to be recovered.

The appropriate hole number and depth in the instrument should be noted above.

Surface Elevation

A level point at the surface at each hole location should be established to within one foot, preferably within one foot, of known elevation nearby, usually the nearest National Geodetic Survey first-order leveling survey marker, to serve as a reference for depth measurements. A survey level, if available, should be used to establish the surface elevation. It is desirable to identify the lateral and vertical coordinates of the datum with respect to geographic coordinates and to the location of the survey staff.

Drilling and Logging

Each hole core is to be taken in each hole to be drilled to a total depth. The core should be at least 3-6 ft long, depending on the largest practically obtainable with a shallow-hole rig. Anticipated total depths are those described in the letter of C. L. Jones (SSGS) to R. D. Seeger (SIA) dated June 7, 1976. It is permissible to drill a total depth, but circulation might be lost, so appropriate additions to the plan are warranted. Completion of all hole operations should be anticipated for water sampling and determination of piezometric elevations and permeability.

Full core recovery (with origin depths documented to within one foot) is highly desirable to facilitate thorough investigation of rocks associated with evaporite dissolution in Nash Draw. However, the exploratory nature of this program takes account of the fact that geologic conditions in these holes are imprecisely known, and might not be conducive to full core recovery. In this case, core obtained should be documented according to actual percentage of recovery, and origin depths of recovered core should be approximately determined through combinations of other techniques, including geophysical logs and comparison with stratigraphically equivalent cores from other holes.

Core should be handled in accordance with established Sandia procedures. These general procedures have been given in the

June 29, 1978

Letter to Distribution from R. D. Statler, 06/11/78,
contains the field operations program for WMP holes B4, B5,
and C.

Geophysical Logging

Three kinds of information are to be obtained by geophysical logging: (1) maintenance of stratigraphic control, identification of rock types in the hole and verification of core depths; (2) identification of fluid-bearing zones and qualitative evaluation of relative permeability for future hydrologic investigations; (3) measurement of up-hole sound-wave velocity, to determine elastic properties of the rock to aid in the interpretation of future seismic surveys at Nash Draw, if any. For example, the first kind of information might entail density, natural gamma, neutron and sonic logs. The second kind might entail R_{XO} , K_{eff} and neutron logs. The third kind might entail sonic and up-hole velocity logs.

Casing

All the holes are to be cased to about 50 feet below the top of salt (past the evaporite residuum at the top of the Salado Formation), using 5-1/2 inches (minimum outside diameter) steel casing, to allow for multiple completion for hydrologic testing at a future time.

Cementing

Cementing of casing is to be accomplished so as to isolate aquifers from one another so that fluids from them do not cross-flow through the cement. Bond logs and tracer testing will be prescribed later during the hydrologic testing program at which time the integrity of the cement behind casing will be evaluated.

Final Operation

After casing and cementing, the holes are to be filled with fresh water and temporarily abandoned, awaiting hydrologic testing.

SJL:5311:rmf

Approved: _____

Lester R. Hill
L. R. Hill, Supervisor
Nuclear Waste Technics
Division 53

APPENDIX B

DRILLING AND TESTING PLAN

by

R. D. Statler
Division 1133

and

P. D. Seward
Division 1135
Sandia Laboratories

INTRODUCTION TO APPENDIX B, DEFINING AND TESTING TERMS

The drilling and testing plan is the translation of technical drawings contained in documents in Appendix A into a series of test points. Changes or amendments are included as well. Test points are primarily obtained from various sources, primarily drawings, but they are not included here.

Field Operations Program of Sandia Labs

WIPP Site Investigations

Nature & Effects of Salt Dissolution, Nash Draw

Exploratory Well:	Nash Draw Location: Sections:
WIPP 25	15, T22S, R30E
WIPP 26	29, T22S, R30E
WIPP 27	21, T21S, R30E
WIPP 28	18, T21S, R31E
WIPP 29	34, T22S, R30E
WIPP 30	33, T21S, R31E

204E
7/2/73

Purpose: To reveal subsurface stratigraphy and hydrologic setting of Nash Draw in order to determine the relation between structures, surface features and evaporate dissolution.

Prepared by *R. D. Staller*
R. D. Staller, Supervisor
Division 1133
Field Engineering Projects

Approved by *John R. Hill*
J. R. Hill, Supervisor
Division 5311
Nuclear Waste Technology

Approved by *John W. McTiernan*
J. W. McTiernan, Supervisor
Division 5342
Nuclear Waste Programs

10/17/78

10/17/78

J. D. Statter

J. D. Statter - 113

See this Laboratory Wells, WHP 25 through 30.

This document contains the Field Operations Plan for conducting WHP
operations in the Nash draw. Drilling, logging, coring, and testing
operations are included for your use and information. Revision and circulation
to be indicated in this document as required and appropriate. Distribution made.

cc:

10/17/78

- 1. J. D. Statter, Special Projects Division, Denver, CO
- 2. J. D. Statter, ES&S/WRD, Albuquerque, NM
- 3. J. D. Statter, ES&S/WRD, Albuquerque, NM
- 4. J. D. Statter, Las Vegas, NV
- 5. J. D. Statter, DOE/ALO
- 6. J. D. Statter, Las Vegas, NV
- 7. J. D. Statter, ES&S, Christal (3)

10/17/78, New

- 1. J. D. Statter
- 2. J. D. Statter
- 3. J. D. Statter
- 4. J. D. Statter (4)
- 5. J. D. Statter (11)
- 6. J. D. Statter
- 7. J. D. Statter
- 8. J. D. Statter
- 9. J. D. Statter
- 10. J. D. Statter (2)
- 11. J. D. Statter (1)

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INTRODUCTION

This document contains design criteria for six exploratory wells to investigate stratigraphy and hydrology in the Nash Draw. It describes the operation and construction of the wells and includes procedures for conducting the field activities required to meet specific objectives. The manual includes procedures with drawings, specifications, and instructions for good quality control of essential features. The final WIPP Site Program Plan for WIPP Site evaluation is expected to be completed in accordance with this field program.

2. TITLE: HEADLINE DRILLING CRITERIA

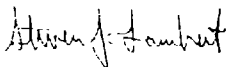
The following memorandum has been accepted as the design criteria for the WIPP. The investigations of the Nash Draw, therefore, it is being approved in its entirety for use in the conduct of this project.

Sandia Laboratories

Albuquerque, New Mexico
87123-5080

3. DATE: June 19, 1978

4. BY: R. E. Statler, 1133



5. FOR: S. J. Lambert, 5311

6. SUBJECT: Criteria for WIPP 25 Through WIPP 30, and Their Quality Assurance

This memorandum is separately reproduced in Appendix A. Pages 1-3 of the drilling and testing program are therefore abridged.

July 24, 1965

II. ORGANIZATION PLAN

A. Organization

Technical direction will originate within Sandia Division 9517, which is operated as, managed by Bob Statler, Sandia Division 1117, will be conducted by W. E. Cunningham, Fenix & Scisson. Drilling contract and associated support service contracts will be let and administered by Fenix & Scisson, arranged for by Federal Agency Order through Nevada Operations Office, 1965.

Identification of marker beds, core logging and their geologic interpretations will be provided by duty geologist.

Quality control and inspection will be conducted by designated experts. Quality assurance program will be administered by E. L. McFarlane and M. Jones, Sandia Division 9517.

Industrial Safety Program will be administered by specialist, E. W. Johnson, Las Vegas.

Administrative assistance, logistical support of Sandia programs will be provided by F. D. Seward and L. E. Magruder, Sandia Division 1117.

July 27, 1976

B. Supporting Data

Geology

The data for the following chart was provided by Charles L. Jones, Geologist, USGS, Special Projects Division, Denver, Co., in a letter from Jones to P. D. Seward, 11/25, dtd 6/7/76.

"Geologic Prognosis for Deep Draw Boreholes"
(Depth Intervals in Feet)

Formation	WIPP 2	WIPP 20	WIPP 21	WIPP 25	WIPP 26	WIPP 27
Unconsolidated Deposits	0-5	0-5	0-15	0-25	0-5	0-25
Carbonate Formation	5-50	NP*	15-50	NP	5	10
Sandstone and Shale	NP	NP	NP	10	NP	NP
Dewey Lake Salt Bed	50-180	NP	50-150	20-160	NP	10-180
Evaporite Formation	180-250	50-200	150-170	280-300	10-110	180-270
Sandstone Deposits	250-275	70-90	170-180	350-370	NP	270-320
Ordovician Deposits	370-470	110-125	270-27	450-470	40-50	370-470
Carbonate Formation	470-600	200-250	300-350	600-700	150-220	470-600
Mississippian Deposits	490-500	270-370	300-370	690-720	25-27	500-600
Unconsolidated	500	370	370	720	270	600

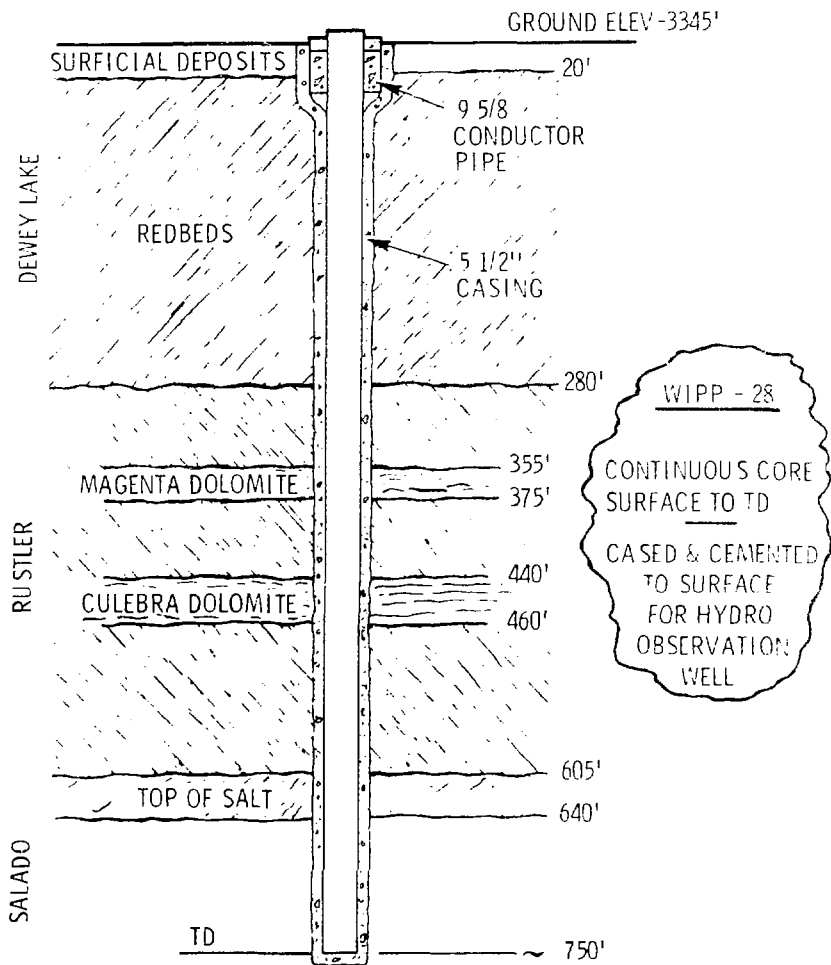
Core Intervals: Core intervals start at total depth of all holes.

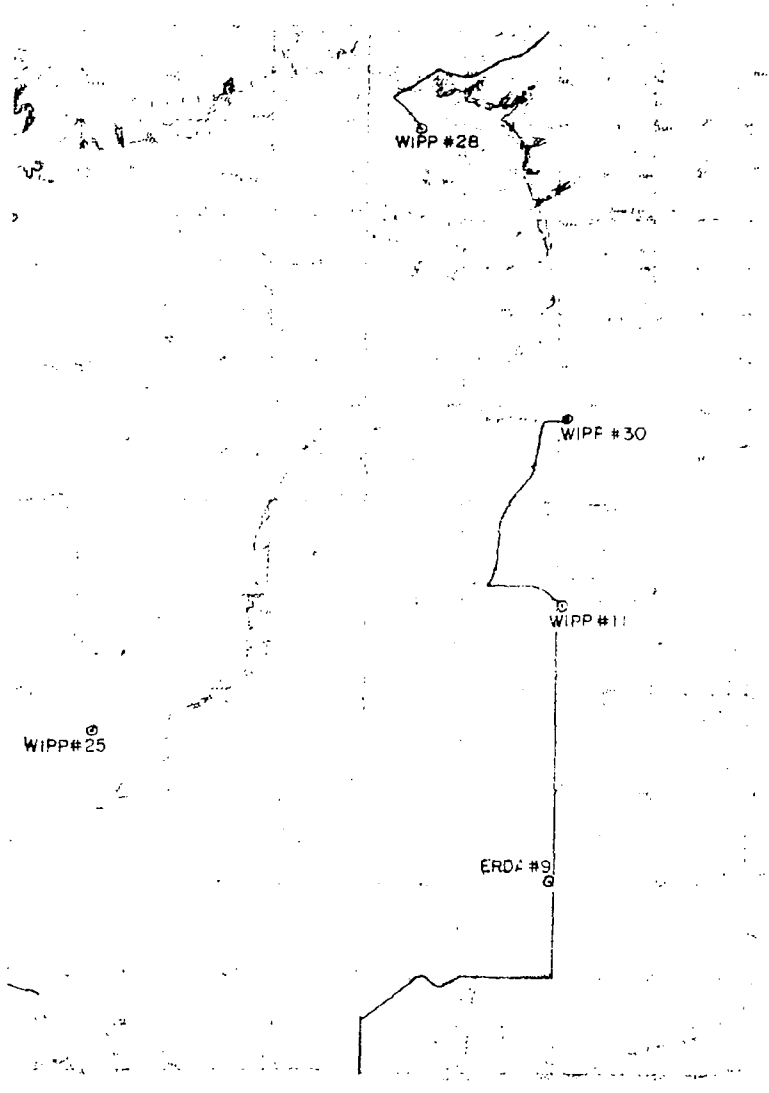
Total Depth: 600 470 370 720 270 600

*NP = Not Present.

Some penetration of fluids as well as zones of lost circulation are expected in each formation.

The full wellbore sketch of WIPP 25 is typical of all holes with the exception of section 2, and thickness of str. formations.





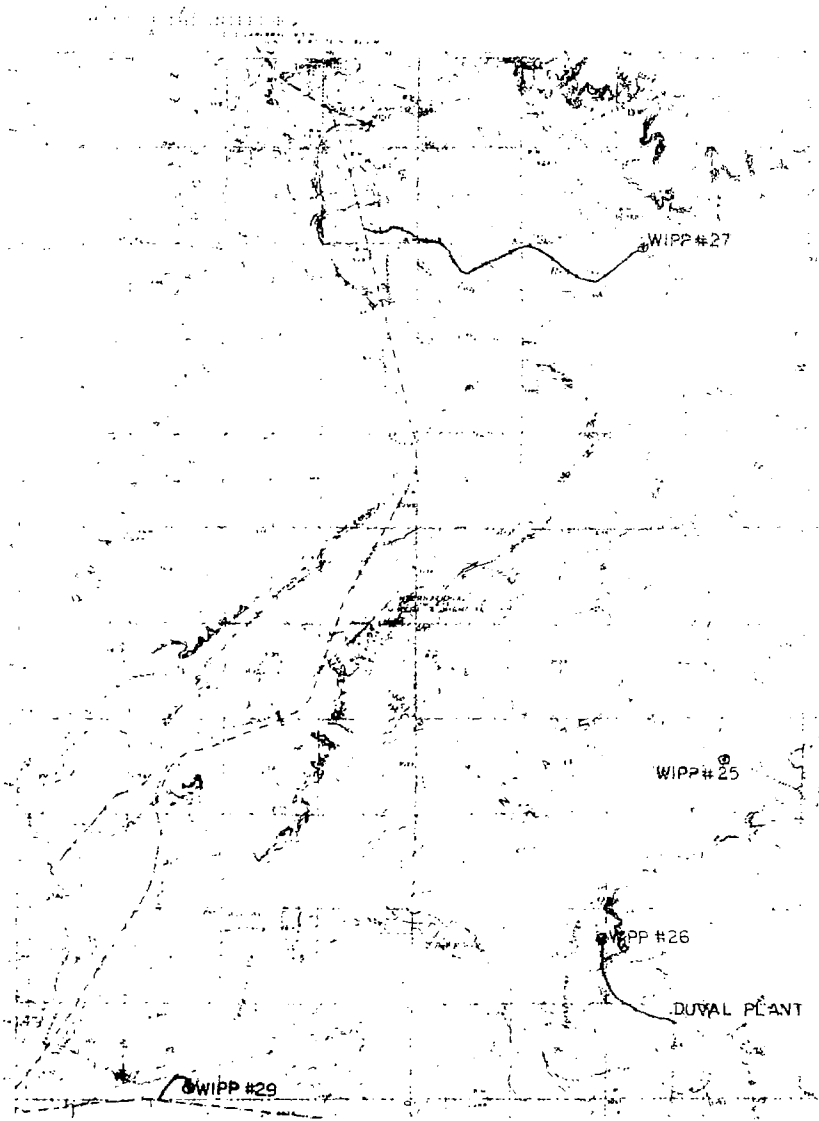
WIPP #28

WIPP #30

WIPP #11

WIPP #25

ERDA #9



WIPP #27

WIPP #25

WIPP #26

DUVAL PLANT

WIPP #29

Jul 26, 1974

- e. Evaluate relative permeabilities
- f. Up-hole sonic velocity
- g. Determine elastic properties of rocks.

The actual commercial logs selected to provide the above information will be established at a later time after a better understanding of the hole conditions is known. Procedures for logging program will be found in Section IV.B.

6. After logging operations are completed, the borehole must be made ready for running casing and cementing. A string of 12-1/2" 13.3 lb/ft 10-55 casing (or reasonable equivalent) with 10-55 cement will be run, stood and cemented to the surface. A prime hole will be run to isolate aquifers from one another and procedures described in Section III. must be followed.
7. Upon completion of casing and cementing, the well must be filled with fresh water and covered with a temporary, temporary cap.
8. Clean up pad areas, fill in pits and leave hole temporarily abandoned for hydrological testing.

10. Discussion of potential hazards

1. Unusual hazards are expected. Some small inert gas pockets may be encountered though unlikely above the salt.

III. FIELD ACTIVITY PROCEDURES FOR QUALITY CONTROL REQUIREMENTS

Portions of this field activity are considered of such a simple nature that quality control measures have been established and these are subject to independent audit by Landis Laboratory Quality Assurance personnel as well as NRC Field Audit Teams. These activities are:

- a. Measurement of Surface Location and Elevation
- b. Core Logging and Handling and Storage
- c. Temperature Logging
- d. Orientation and Correlating

These activities will be monitored in detail or reviewed by independent quality control experts whose education, experience and expertise make them qualified to do so. Adherence to operating procedures and to certain activities that demand objectives have been met.

When so required, this is usually done by appropriate procedures negotiated with pertinent officials to assure consistent procedures and acceptable results.

3. Measurement of Surface Position and Elevation

The general location will be established by Dredging Unit File No. 1000. The location of the study area, surface features, and elevation will be determined by the following methods. A preliminary land survey will be conducted by a Registered Land Surveyor to establish a network of control points around the area and provide a barrier between the study area and the adjacent land. The network will be established with nearest section boundaries and that of the adjacent owners to provide data necessary to establish a network of control points for whether surface features are to be measured. After the construction is complete and at the time of the survey, a concrete monument with a brass cap will be set in the center of each of the parcels such that it can be used as the datum point for all vertical measurements. Since this monument is established by the intersection of lateral relations, the horizontal distance between the Registered Land Surveyor's established vertical monument within the study area and the lateral monument will be established by nearest section boundaries and registered landowners. All field notes utilized in conducting the "preliminary" survey will be written and a copy of the notes submitted to the Dredging Unit. A copy of the survey shall be submitted to the Dredging Unit with a copy of the original copy of the map relative to the area.

B. Core Logging and Handling and Storage

A duty geologist will log and measure core as it is removed from the barrel. When drill cuttings are required, duty geologist will see they they have been taken, washed and dried. They should then be tied in 10' bundles, boxed, and marked with well identity, and interval taken. Storage will then be taken to core storage in Carlshadalm, with core.

A record should be kept showing date and hour, sequence of core intervals, log and interval, location of core recovered, and percentage. If significant intervals are missing, the depth and interval of missing core should be recorded as well as any determined depth of penetration of the formation. Run operating conditions such as RPM, weight on bit, and bottom pressure should also be kept.

For ease of consistency, a routine has been established for handling of rockbit core at the drill pad as follows:

1. Routine contractor and roustabouts will run barrels from and into barrels. The duty geologist will supervise the run in and record and placement in troughs in the order they come out of barrels for inspection and measurement. Tronors are marked with depth and interval by top end and base and carried down the hole.
2. At the end of a run for a run, each man will be responsible for a core section a water meter, slack-link, and a pair of forceps. The meter is to determine interval. Slack-link and forceps are to be marked as described above and placed in water bucket with a 10' scale below them.
3. Log, interval, depth, and location of core should be recorded on a log sheet and placed in a separate file folder for each well. Water and log sheets should be on the right side of the Kelly pushbar in Post office - special file.
4. Meter run in and out the slot and separate into appropriate sections. Meter and seal and insert into a well shape boxes in appropriate order of well identity and location of core interval.
5. Transport the boxed core to core storage in truck and deliver core in facility and delivery to avoid core damage.
6. The duty geologist will be responsible for assuring correct marking of the exterior of all core boxes, date packaging, and transport to the drill pad for delivery to core storage. Location and heading entries on the Well Core Logging Record should follow same quantities and units as are delivery to core storage.

1. Geophysical Logging

1. Prior to logging, a Sandia representative will meet with the Logging engineer, present "Instructions to Logging Co." as shown on following pages, and discuss:
 - a. The entire logging program and any special requirements.
 - b. Hole conditions that may cause problems.
 - c. Zone of special interest.
2. The equipment will be "warmed up" for the adequate amount of time and tools will be checked to see that they are functioning properly upon arrival at the location.
3. R_{sp} , R_{mn} , and R_{sc} will be measured on mud samples. Estimated values are not acceptable. The service company should run the sample through a mud press.
4. Printer scales will be used on each log.
5. All Litho, Log and Compensated Neutron logs and all density porosity curves will be run on limestone matrix over the zone of interest, regardless of the lithology.
6. Equipment will be tested while running in hole.
7. Before and after log calibrations will be shown for all curves.
8. Band calibration will be shown for all density and neutron logs, integration checks will be shown for all Integrated Acoustic logs.
9. In addition to caliper rings the caliper calibration should show "tool bit open" and casing readings.
10. Minimum 200 foot repeat must be shown.
11. Section intervals run by at least 200 feet.
12. All available information will be completely filled out.
13. A "Quality Report" such as is shown on following pages will be completed by qualified Sandia representative.

IDENTIFICATION OF SUBJECTS

Name of Subject: _____
Date of Birth: _____
Place of Birth: _____

Address: _____
City: _____ State: _____ Zip: _____

Occupation: _____
Education: _____

Religion: _____
Marital Status: _____

Place of Employment: _____
Employer: _____

Character of Employment: _____
Date of Employment: _____

Character of Residence: _____
Date of Residence: _____

Character of Vehicle: _____
Date of Vehicle: _____

Character of Vehicle: _____
Date of Vehicle: _____

Character of Vehicle: _____
Date of Vehicle: _____

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Character of Vehicle: _____
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Character of Vehicle: _____
Date of Vehicle: _____

Character of Vehicle: _____
Date of Vehicle: _____

July 26, 1978

b. Casing and cementing

1. Inspect casing to be run. Sand blast if necessary to remove severe rust flakes. Pits of rust without flakes may actually enhance bonding.
2. Condition hole, run if necessary to remove tight places.
3. Condition fluid until mostly free of cuttings.
4. Install combination float shoe.
5. Run casing with centralizer. Utilize logs to determine location as well as routine spacing of 66-96 feet apart.
6. Begin pumping and displace well fluid with mud flush, then set, and cement slurry. Use 70-80 per mix, salt to saturation, and 2% bentonite gel.
7. Displacement rate approximately 2-1/2 barrels per minute.
8. Pump plug with approximately 500 psi over pumping-mixing rate. Mix 1000 psi, close in head.
9. 20-30 hours.
10. Apply mud after 36 hours.

Note: Observe regulations issued by State Engineer; in particular, requirement that "casing shall not be installed or cemented without a permit notified to the State Engineer Office."

10. FIELD:

a. Distribution Instructions:

1. Daily Reports:

1 - Las, Carlsbad, shall provide to Sandia, Carlsbad, a copy of the daily reports. Sandia, Carlsbad, will telefax weekdays to B. Summers, Box 400, Route 6, Mill, 5311, Albuq., who will mail copies to McFarlane, 1131, Roswell, 1135, and Statler, 1133. A copy of the daily report is to be kept by Sandia, Carlsbad.

2. Daily History:

1 - Las, Carlsbad, and Las Vegas, NV. Send copy to Statler, 1133, for Sandia, Albuquerque, dissemination.

3. Geological Log:

1 - Las, Carlsbad, shall obtain nine copies of Field geologic logs. Final distribution to include the following:

- 1 - Las, Carlsbad
- 1 - G. Jones, USGS, Spec. Procl. Div., Denver, CO
- 1 - G. Moyer, USGS/WKD, Albuq., NM
- 1 - G. G. Bachman, USGS/WKD, Albuq., NM
- 1 - D. W. Powers, 5311, SLA
- 1 - Las, Carlsbad

4. Loggram, shall order 19 Final copies for dissemination as follows:

- 1 - Las, Carlsbad
- 1 - Las, Las Vegas
- 1 - Sandia, Carlsbad
- 1 - G. Jones, USGS, Spec. Procl. Div., Denver, CO
- 1 - G. G. Bachman, USGS/WKD, Albuq., NM
- 1 - S. J. Lambert, 5311, SLA
- 1 - D. W. Powers, 5311, SLA
- 1 - State Archives, w/original, tapes and film
- 1 - State Engineer, Roswell, NM
- 1 - USGS Area Geologist, Roswell, NM
- 1 - West Texas Electric Log Service

5. Miscellaneous Reports shall be provided to Las, Carlsbad, include:

1 - The following, with original, to be kept on file at Las, Carlsbad, and to be kept at Sandia, Carlsbad:

- 1 - Miller Log, Bit Records, Drill Fluid Recaps
- 1 - Drilling Certification
- 1 - Drilling History Chart
- 1 - Miscellaneous Reports to R. D. Statler, 1131, Albuq.

Date August 15, 1978

To Distribution



From K. D. Statler:1133

Subject Supplement #1 to Field Operating Program WIPP #25 thru #30

The following additions and modifications to the Field Operating Program for the Nash Draw Exploratory Wells, WIPP #25 thru #30 are forwarded for your use and information:

- A. Fourteen (14) copies of the As Built Survey of the hole location should be distributed as follows:
1. Fenix & Seiszon-Carlsbad
 2. Fenix & Seiszon-Las Vegas
 3. Sandia-Carlsbad
 4. Sandia-K. D. Statler:1133 (2 copies)
 5. Sandia-P. D. Seward:1135
 6. C. Jones-USGS, Special Project Div., Denver, CO
 7. G. O. Bachman, USGS-WRD
 8. T. Meyer, USGS-WRD
 9. S. J. Lambert:5311, SIA-A15
 10. Archive:5549 (2 copies)
 11. New Mexico State Engineer, Roswell, NM
 12. Area Geologist, Roswell, NM
- B. The Run Geophysical logs up to the highest level that will hold fluid - Estimated to be 2220-feet.
- C. To be run as follows:
1. Density
 2. EMI Acoustilog
 3. Micro Laterolog
 4. Tool Bit-logs
 5. Temperature/Pressure
 6. "Dr Hole Velocity"
- D. And to be run by S-48K to distribution of all logs.
- E. Core handling and Storage procedures are modified to include photography of core at the drill site as soon as it has been logged and identified by the Duty Geologist and before it is sleeved for storage.
- F. Six copies of all core photographs are to be made by Sandia Laboratories and distributed as follows:
- 3 Copies - Division 5311
 - 1 Copy - C. L. Jones, USGS, Denver, CO
 - 1 Copy - G. O. Bachman, USGS-WRD

APPENDIX C

HOLE HISTORY

by

R. D. Statler

Division 1133

and

P. D. Seward

Division 1135

Sandia Laboratories

INTRODUCTION TO APPENDIX C, HOLE HISTORY

The hole history is a document provided soon after completion of the wellbore, and it summarizes the relevant information in the daily time logs kept by the contractor. The hole history is not edited to ensure compliance in every detail with later information developed by project operators. Further information may be obtained as necessary through examination of the original daily time logs.

FENX & SCISSON, INC

HOLE HISTORY DATA

11-16-78

HOLE NO.	HIPP #29		K.O. No.	_____		
OPER	Sandia Lab.		TYPE HOLE	Exploratory		
LOCATION	New Mexico		COUNTY	Eddy		
SURFACE COORDINATES	* 711.97' PSL, 1826.66' TEL		GROUND ELEVATION	* _____		
POSITION LOCATION	_____		SPROUDED	10-3-78		
CIRCULATING MEDIA	* 1" FASO 100'					
NO. OF COMPRESSORS & SIZE						
BORE HOLE RECORD			CASING RECORD			
FROM	TO	SIZE	I. D.	WT. FT.	WALL	GRADE
0'	135'	6-3/4"				
135'	377'	7-7/8"	**			1-95' STAG + 0.6'
TOTAL DEPTH:	377'	MANDREL DEPTH	_____			
JUNK						
LOGGING DATA	Page # _____		SURFACE PAGE	_____		
BOTTOM HOLE COORDINATES			REFERENCE			
NON-OPERATIONAL TIME			OPERATIONAL DELAY TIME		WORKING TIME	
Make Rig up & down	_____ days	Equipment Repair	_____ days	Drilling Time, Peening	_____ days	_____ days
Secured	1.07 days	Coring	_____ days	Tripping Time	_____ days	_____ days
Barl & Run Mandrel	_____ days	Lost Circ.	_____ days	Single Shot Survey Time	_____ days	_____ days
Logging	0.66 days	Fishing	_____ days	Coring	_____ days	2.21 days
Survey	_____ days	M. O. Equipment	_____ days	Total	_____ days	4.49 days
Casing, Run & Cement	0.46 days	Fix & Condition Pul	0.32 days	Total Suspended Time	_____ days	_____ days
Cement	_____ days	_____	_____ days	Non-Operational Time	_____ days	2.21 days
Coring	_____ days	_____	_____ days	Operational Delay Time	_____ days	0.32 days
Rig & Pull 4-1/2" CS.	0.10 days	_____	_____ days	Working Time	_____ days	4.49 days
TOTAL	2.21 days	TOTAL	0.32 days	TOTAL ELAPSED TIME	_____ days	7.03 days
REMARKS						
* Brass mandrel location: 404.18' PSL, 1826.44' TEL, Sec. 34, T2S, R 296 Elevation 2976.99'						
			Rig No.	Name	Type	
** CASING I. D.	WT./FT.	INTERVAL	1	Pe	Drilling Co. Pulling 2000' 7.03 days	
5.012"	14.00#	+ 0.6' - 11.85'			_____ days	
4.956"	10.50#	11.85' - 376'			_____ days	
					_____ days	
					_____ days	
UNDS:jt					_____ days	

LOG INDEX SHEET

LOG DATE	WELL NO.	DEPTH DRILLED	DEPTH LOGGED	LOG NO.	LOG DATE
WESPER HILL LOGS					
10-10-76	1	377	358	1	10-10-76
10-10-76	1	377	360	2	10-10-76
10-10-76	1	377	360	3	10-10-76
10-10-76	1	377	360	4	10-10-76
10-10-76	1	377	360	5	10-10-76

MUSIC MESSING TITMUS LOGS

10-11-76	1	377	355	1	10-11-76
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NOTE: Logs furnished F&M Mercury.

WIPP # CORE RECORD

Page 1

DEPTH	INTERVAL	FEET	RPM	WEIGHT ON BIT	CIRCULATING PRESSURE P. S. I.	FEET CORED	FEET RECOVERED	% RECOVER
		71.5			UsBar Shelby Tubes	2.7		
		71.8			Cores 1 - 3	1.6		
		73				1.7		
		73.5		2000	150	2.5		
		73.6	50	"	"	1.5		
		73.9	50	"	"	3		
		73.9	111	"	100	5.1		
		74	110	"	"	8.5		
		76.75	110	"	"	4.75		
		77.75	110	"	"	7.0		
		78.5	120	"	"	5.25		
		78.5	150	4000	200	5.0		
		79	150	"	"	9.0		
		79	150	"	"	10		
		79	150	"	"	20		
		80	150	"	"	3		
		80	"	"	"	5		
		89	"	"	"	2		
		89	"	"	"	2		
		90	"	"	"	1	5.0	50
		90	"	"	"	4	1.8	45
		99	"	"	"	3	3.0	100
		102	"	"	"	6	5.5	100
		108	110.9	120	"	7.9	2.9	100
		110.9	116	"	"	5.1	5.3	100
26	116	118	"	"	"	2	2.0	100
27	118	121	"	"	"	3	3.00	100
28	121	130	150	3000	200 C-5	9	8.6	96

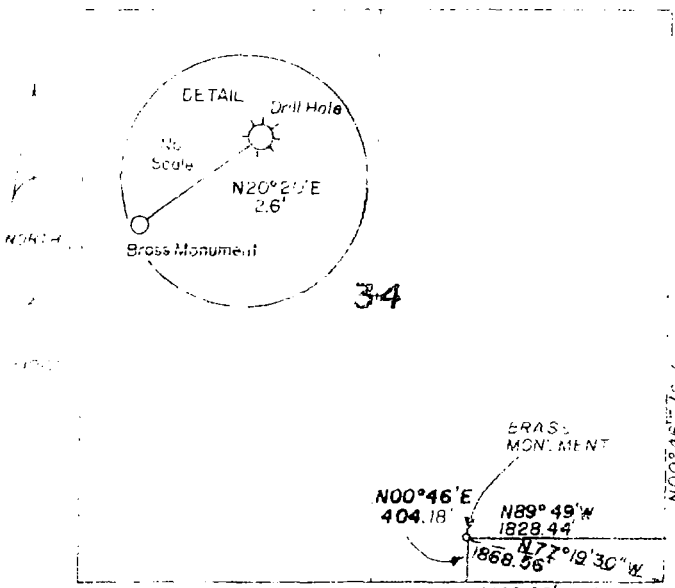
WIPP # 24 CORE RECORD

CORE NO.	INTERVAL	FEET	RPM	WEIGHT ON BIT	CIRCULATING PRESSURE P. S. I.	FEET CORED	FEET RECOVERED	PER. JOE
50	136	135	120	3900	250	9	9.6	102
51	140	139	90	3500	250	7	9.2	102
52	144	143	120	3000	250	2.5	2.5	102
53	148	147	"	"	"	3.5	3.5	102
54	152	151	"	"	"	4	4	102
55	156	155	"	"	"	4	4	102
56	160	159	"	"	"	4	4	102
57	164	163	"	"	"	4	4	102
58	168	167	"	"	"	4	4	102
59	172	171	"	"	"	4	4	102
60	176	175	"	"	"	4	4	102
61	180	179	"	"	"	4	4	102
62	184	183	"	"	"	4	4	102
63	188	187	"	"	"	4	4	102
64	192	191	"	"	"	4	4	102
65	196	195	"	"	"	4	4	102
66	200	199	"	"	"	4	4	102
67	204	203	"	"	"	4	4	102
68	208	207	"	"	"	4	4	102
69	212	211	"	"	"	4	4	102
70	216	215	"	"	"	4	4	102
71	220	219	"	"	"	4	4	102
72	224	223	"	"	"	4	4	102
73	228	227	"	"	"	4	4	102
74	232	231	"	"	"	4	4	102
75	236	235	"	"	"	4	4	102
76	240	239	"	"	"	4	4	102
77	244	243	"	"	"	4	4	102
78	248	247	"	"	"	4	4	102
79	252	251	"	"	"	4	4	102
80	256	255	"	"	"	4	4	102
81	260	259	"	"	"	4	4	102
82	264	263	"	"	"	4	4	102
83	268	267	"	"	"	4	4	102
84	272	271	"	"	"	4	4	102
85	276	275	"	"	"	4	4	102
86	280	279	"	"	"	4	4	102
87	284	283	"	"	"	4	4	102
88	288	287	"	"	"	4	4	102
89	292	291	"	"	"	4	4	102
90	296	295	"	"	"	4	4	102
91	300	299	"	"	"	4	4	102
92	304	303	"	"	"	4	4	102
93	308	307	"	"	"	4	4	102
94	312	311	"	"	"	4	4	102
95	316	315	"	"	"	4	4	102
96	320	319	"	"	"	4	4	102
97	324	323	"	"	"	4	4	102
98	328	327	"	"	"	4	4	102
99	332	331	"	"	"	4	4	102
100	336	335	"	"	"	4	4	102
101	340	339	"	"	"	4	4	102
102	344	343	"	"	"	4	4	102
103	348	347	"	"	"	4	4	102
104	352	351	"	"	"	4	4	102
105	356	355	"	"	"	4	4	102

SURVEY MONUMENT "AS BUILT"
"WIPP 29"

SECTION 34, TOWNSHIP 22 S, RANGE 29 E N.M.P.M.
 EDDY COUNTY, NEW MEXICO

ELEVATION OF BRASS MONUMENT 2976.99'
404.18' FS; 8 1828.44' FEL



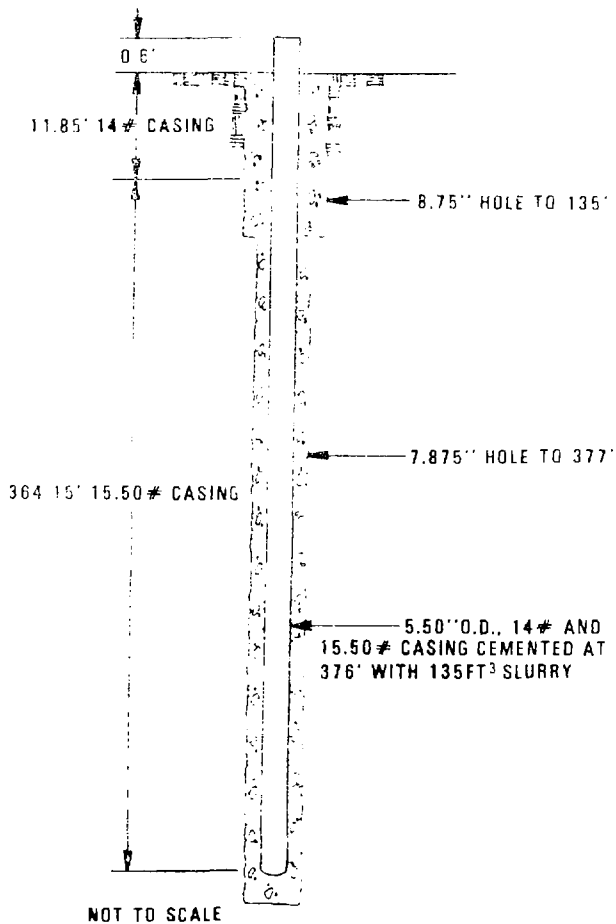
34

This is to certify that the foregoing plat was made from field notes of a bonafide survey made by me and is true and correct to the best of my knowledge and belief

Dan R Reddy
 Dan R Reddy
 N.M.P.E.&L.S #5412



WIPP #29
AS BUILT HOLE CONDITIONS
AS OF 10/10/78



APPENDIX D

LOGS

by

S-E. Shaffer
Division 4511
Sandia Laboratories

1. I am a
2. I am a
3. I am a
4. I am a

1. I am a
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