DOE/WIPP-08-3375

Basic Data Report
for
Piezometers PZ-13, PZ-14, and PZ-15
and
Shallow Subsurface Water

U.S. Department of Energy

Revision 1

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ABSTRACT

The Site and Preliminary Design Validation (SPDV) pile is located in the southwest corner of Section 21, Township 22 South, Range 31 East in Eddy County, New Mexico, adjacent to the Waste Isolation Pilot Plant (WIPP) operational area. During August 2007, piezometers (PZ)-13, PZ-14, and PZ-15 were drilled around the SPDV pile to determine if shallow subsurface water (SSW) existed around the SPDV pile and, if so, provide a means to monitor. These piezometers were drilled with a combination of hollow-stem auger and air-assisted hollow-stem auger drilling. Below the surficial dunes and Berino soil, piezometers PZ-13 and PZ-14 encountered in order, from shallowest to deepest, the Mescalero caliche, Gatuña Formation, Santa Rosa Formation, and Dewey Lake Formation. Piezometer PZ-15 was completed in the Gatuña Formation, having not encountered the lower formations by the time SSW was detected.

Water was encountered in all wells. Piezometers were constructed of 2-inch polyvinyl chloride casing and 15 feet of 0.020-inch slot screen. Water samples were obtained and analyzed for each well. Based on the results of the installation of the piezometers, analysis of water levels, and geological analysis, it is concluded that the water levels identified in PZ-13 and PZ-14 are the result of the SPDV pile runoff or infiltration prior to being lined. Water in PZ-15 is much shallower and chemically different that water in the other two wells, indicating another source, such as recharge and infiltration from the east of the SPDV pile.

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1.0 INTRODUCTION

The Site and Preliminary Design Validation (SPDV) pile is located in the southwest corner of Section 21, Township 22 South, Range 31 East, Eddy County, New Mexico, adjacent to the Waste Isolation Pilot Plant (WIPP) operational area (Figure 1-1). Piezometers PZ-13, PZ-14, and PZ-15 are located around the SPDV pile as indicated in Figure 1-2. These piezometers were drilled to determine if shallow subsurface water (SSW) existed around the SPDV pile and, if so, to provide a means to monitor the water level and quality.

Most drillholes near 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. This basic data report provides details and descriptions of the drilling procedures and activities utilized during the installation of PZ-13, PZ-14, and PZ-15 that may be helpful to later interpretations of data or for further work in the drillhole, such as test activities and plugging and abandonment.

1.1 Purpose of WIPP and the SPDV Pile

WIPP is a transuranic mixed waste disposal facility operated by the U.S. Department of Energy (DOE). WIPP waste is disposed in the Salado Formation, a bedded salt deposit, 2,150 feet below ground surface (bgs). Salt and other mined rock materials from the construction of WIPP and currently mined salt are stored on the surface in three stockpiles. The stockpiles include, from oldest to newest, the SPDV pile closed in 2000 with an engineered cover; the salt storage area (SSA), which was used previously for mined salt and materials, but recently covered with a synthetic and earthen liner, and the Salt Storage Extension (SSE) for currently mined salt. The focus of this investigation was the SPDV pile.

The SPDV pile was created during the WIPP design validation phase for placement of construction materials resulting from drilling of two 2,150-foot shafts and the underground excavation of connecting tunnels, exploratory tunnels, and four rooms. The materials in the SPDV pile include mined tailings interspersed with soil, rock, and debris from the construction of the shafts. The SPDV pile encompasses approximately 168,000 cubic yards, which includes an area beneath the pile where soil was excavated prior to tailings placement.

The SPDV pile was characterized in 1995 by Daniel B. Stephens and Associates to determine the chemical nature of wastes within the pile and to support selection of reclamation alternatives (Daniel B. Stephens and Associates, Inc., 1996). The investigation determined that no remedial measures were required according to New Mexico Environment Department (NMED) guidelines. As a result of the study, stabilization and reclamation were recommended in order to prevent off-site transport of salt and brine solutions into the surrounding environment, and to blend the salt pile into the surrounding environment. Based on the evaluation, the SPDV pile was formally closed in 2000 by covering it with geosynthetic clay liner installed on 6 inches of bedded material and covered with a minimum of 3 feet of earthen material. The entire SPDV pile was seeded with shallow rooted plants, which have successfully established.

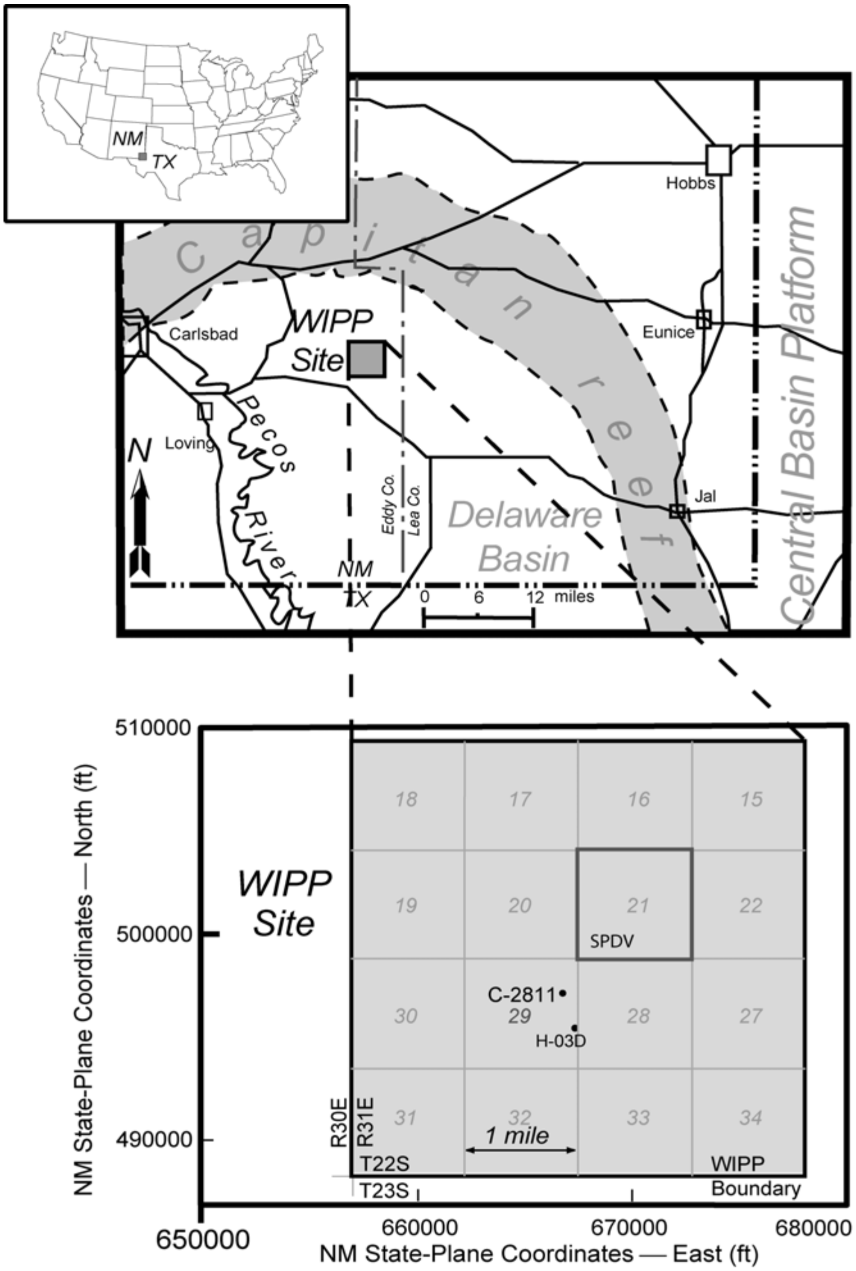


Figure 1-1 - Location Map

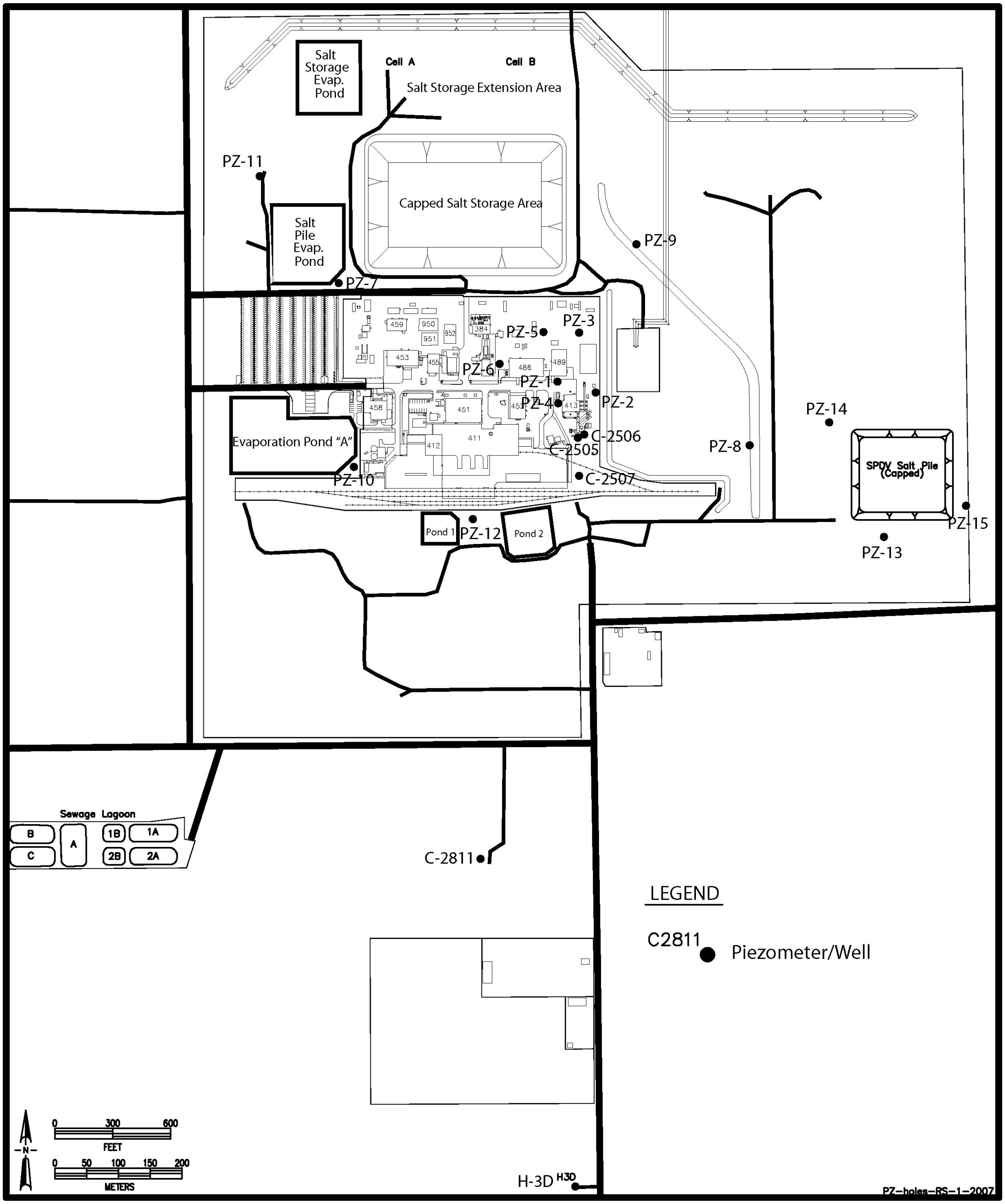


Figure 1-2 - Map of the WIPP Operational Area Showing the Location of Piezometers PZ-13, PZ-14, and PZ-15

1.2 Purpose of PZ-13, PZ-14, and PZ-15

SSW was first detected in 1995 when a video inspection of the Exhaust Shaft detected seepage from about 50 to 80 feet bgs. After 1995, a series of hydrologic assessments were undertaken to identify the source and nature of the SSW at WIPP. Sixteen wells were installed (Figure 1-2) to assess the SSW. It is important to note that the area of interest to this assessment was the exhaust shaft and surface features such as the old salt pile, salt pile evaporation pond, and Ponds 1 and 2. The assessment excluded the SPDV pile. The SSW is a shallow perched water bearing zone that sits on a permeability change at the formational contact between the Santa Rosa Formation and the upper Dewey Lake Formation. The SSW is anthropogenic in nature, resulting from infiltration of precipitation that was captured by unlined ponds and stockpiles (see discharge permit DP-831 for details).

In December 2003, the NMED Ground Water Quality Bureau (GWQB) issued a modified DP-831 requiring that the unlined ponds and stockpiles be lined with a synthetic liner: SSA and Salt Pile Evaporation Pond (SPEP), Ponds 1 and 2, Pond A. Additionally, a new SSE was to be constructed with a synthetically lined base on which infiltration and surface runoff from this pile would be directed to a new evaporation basin. Also included in this modification was the implementation of a monitoring program of the SSW that included quarterly water level measurements from all the SSW wells and semiannual sampling of selected SSW wells for total dissolved solids (TDS), chloride, sulfate, nitrate, chromium, and selenium. This program was implemented in May 2004 and continues to date.

On December 29, 2006, the NMED GWQB issued another DP-831 modification with a condition that the SPDV pile be investigated as a possible source of shallow groundwater. The modification indicated that WIPP should install three monitoring wells adjacent to the SPDV pile. Piezometers PZ-13, PZ-14, and PZ-15 were drilled during August 2007 around the SPDV pile to investigate the possibility of SSW beneath the subsurface.

Prior to this investigation, the only other drilling in the area was by Daniel B. Stephens and Associates (1996) to characterize the content of the SPDV pile, and Sergent, Hauskins & Beckwith (1979), for geotechnical data collection and analysis. No water was detected in either of these investigations. Prior to drilling the SPDV pile piezometers, it was hypothesized that SSW, if present, would be perched on the contact between the Santa Rosa Formation and the Dewey Lake Formation, as it had at locations west of the SPDV pile. The best estimated depth for piezometers PZ-13, PZ-14, and PZ-15 was 60 feet bgs, based on PZ-8, which is located west of the SPDV pile.

This report summarizes the installation of the piezometers around the SPDV pile and correlates the data to the data for the other SSW piezometers around WIPP via interpretation of hydrology and chemistry.

2.0 GEOLOGICAL DATA

2.1 General Geological Background

The geology and hydrology of formations at the WIPP site and the surrounding area have been investigated since 1975, and the information and interpretations have been reported in numerous documents. The most thorough compilation is the Compliance Certification Application (CCA) submitted in 1996 by the DOE to the U.S. Environmental Agency (U.S. DOE, 1996). Some features of the broader geological history are relevant to understanding the geology and hydrology at the location of the SPDV pile and the piezometers associated with this report (Powers,1997).

The Delaware Basin (Figure 1-1) was a large structural feature that controlled deposition through much of the Paleozoic. By late Permian, the basin was restricted, and evaporite minerals dominated. The basin filled with sediments, and it no longer significantly affected sedimentation. Near the end of the Permian, circulation with the ocean improved, and some of the Rustler Formation was deposited in saline water rather than brine. As the Permian ended and Triassic began, continental environments prevailed and significant redbeds, the Dewey Lake Formation (Figure 2-1), were deposited. Although surrounding areas accumulated variable thicknesses of later Mesozoic and Cenozoic age sediments, the WIPP area appears to have mainly been subjected to erosion during an extended period from mid-Mesozoic to mid-Cenozoic (Figure 2-1). Some basin tilting around mid-Cenozoic exposed the evaporite beds to faster solution and erosion, and weathered material accumulated. The Pecos River drainage became integrated through the region during this period, and late Cenozoic deposits reflect this sedimentary environment and sediment sources outside the local area. Although the region is still subject to evaporite dissolution and erosion, large areas have remained geologically stable for about the last half-million years, resulting in the formation and preservation of pedogenic calcrete (Mescalero caliche) deposits (Powers 1997).

Three sources of information contribute to understanding the geology of PZ-13, PZ-14, and PZ-15: (1) the general near surface geology of this area (Powers 1997), (2) drilling and logging of shallow piezometers in the vicinity, and (3) core samples and cuttings collected during drilling. Formation color was determined using Munsell Soil Color Charts, year 2000 revised edition.

These piezometers were drilled by hollow-stem auger with split spoon sampling and air-assisted hollow-stem auger drilling, depending on the formation and consolidation. Contact depths to each formation were predicted prior to drilling based on those identified in piezometers PZ-8 and PZ-9 (Figure 1-2). Actual contact depths ranged from 11 feet deeper to 11 feet shallower than anticipated for any formation compared to these to piezometers (Table 2-1).

2.2 Geological Data From PZ-13

2.2.1 Permo-Triassic Dewey Lake Formation

The Dewey Lake was encountered in PZ-13 from 75 feet deep to total depth (TD) of the piezometer at 77 feet (Figure 2-2). The Dewey Lake in PZ-13 is dominated by dark reddish brown silty mudstone with mottling of red and gray-olive gray mudstone, with greenish gray reduction spots. The formation was platy, reflecting common thin bedding or laminae of the unit, contained some moisture at the Santa Rosa contact, but dried as the drilling proceeded deeper. This indicated that the upper portion of the Dewey Lake was acting as an aquitard, and drilling was stopped. A well was installed at this location and constructed as depicted in Figure 2-2.

The Dewey Lake at PZ-13 was encountered 11 feet deeper in elevation than it was in PZ-8, indicating possible erosion during deposition of the overlying Santa Rosa Formation during predominantly fluvial environments. The Dewey Lake was 3 feet deeper in elevation in PZ-13 than in PZ-9, another previously installed piezometer in the area. It was about 2 feet deeper in elevation than PZ-14 (Section 2.3).

Table 2-1 - Encountered Contacts of Each New Piezometer Relative to PZ-8, PZ-9, and Each Other

Formation	Well	Encountered Contact Relative to Piezometer Drillholes ("+" indicates deeper)				
		PZ-8	**PZ-9**	**PZ-13**	**PZ-14**	**PZ-15**
Dewey Lake	PZ-13	+11	+3	NA	+2	Not Encountered
	PZ-14	+9	-0.5		NA	Not Encountered
	PZ-15	Not Encountered	Not Encountered	Not Encountered	Not Encountered	NA
Santa Rosa	PZ-13	0	-2	NA	+2	-7
	PZ-14	+9	+1		NA	
	PZ-15	+7	+5			NA
Gatuña	PZ-13	-3	-2	NA	0	-4
	PZ-14	-3	-2		NA	
	PZ-15	-10	-2			NA

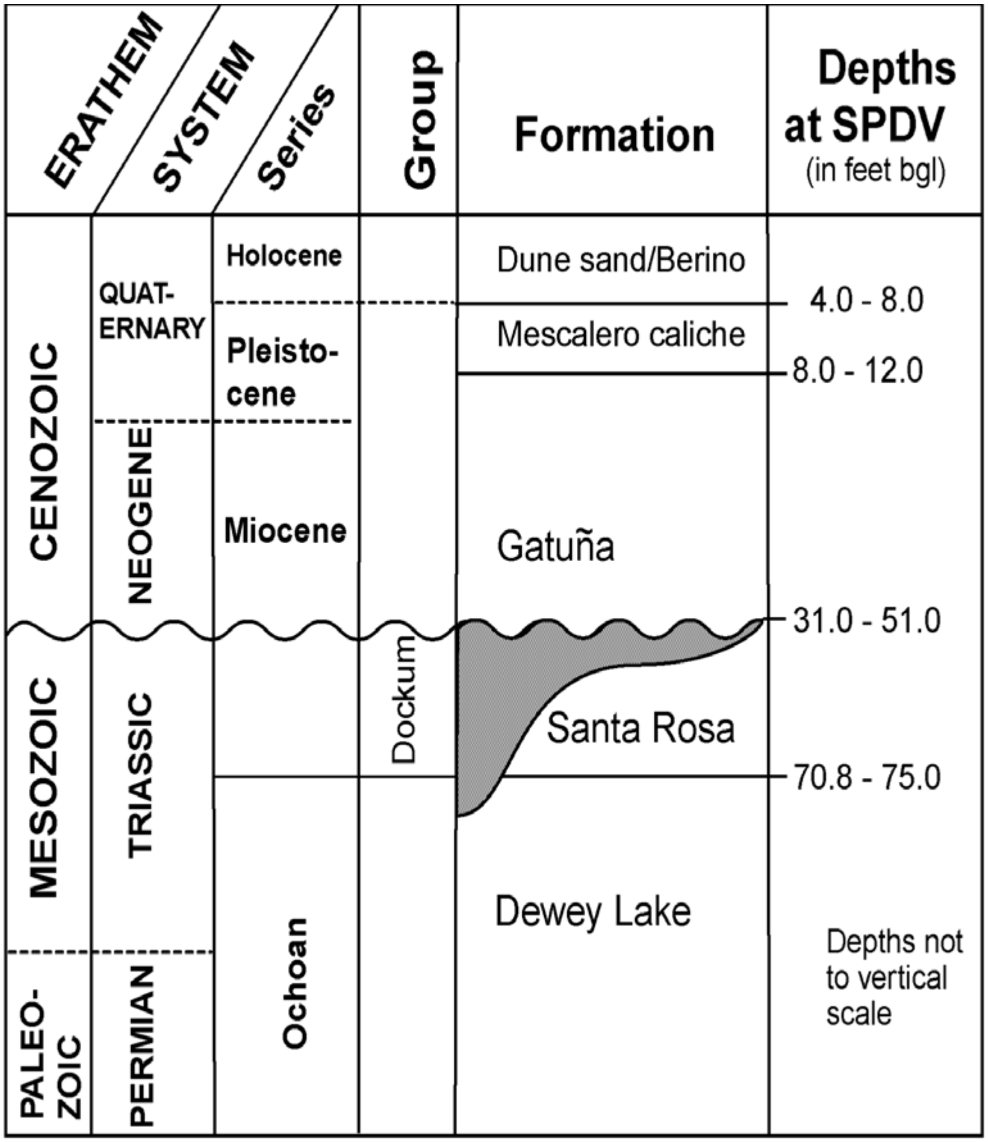
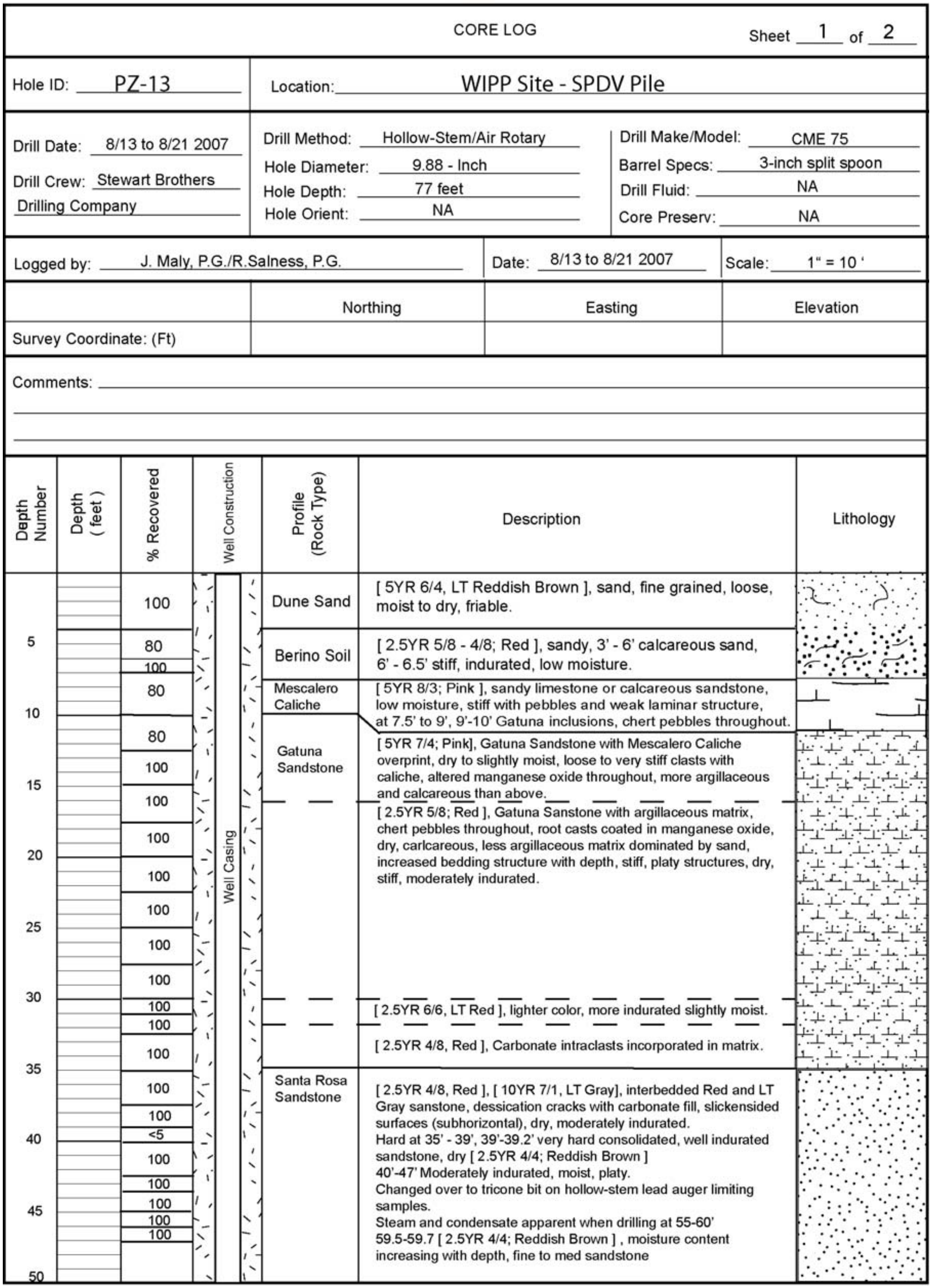


Figure 2-1 - Generalized Stratigraphy Encountered at the SPDV



CORE LOG

Sheet 1 of 2

Hole ID: PZ-13

Location: WIPP Site - SPDV Pile

Drill Date: 8/13 to 8/21 2007

Drill Crew: Stewart Brothers Drilling Company

Drill Method: Hollow-Stem/Air Rotary

Hole Diameter: 9.88 - Inch

Hole Depth: 77 feet

Hole Orient: NA

Drill Make/Model: CME 75

Barrel Specs: 3-inch split spoon

Drill Fluid: NA

Core Preserv: NA

Logged by: J. Maly, P.G./R.Salness, P.G.

Date: 8/13 to 8/21 2007

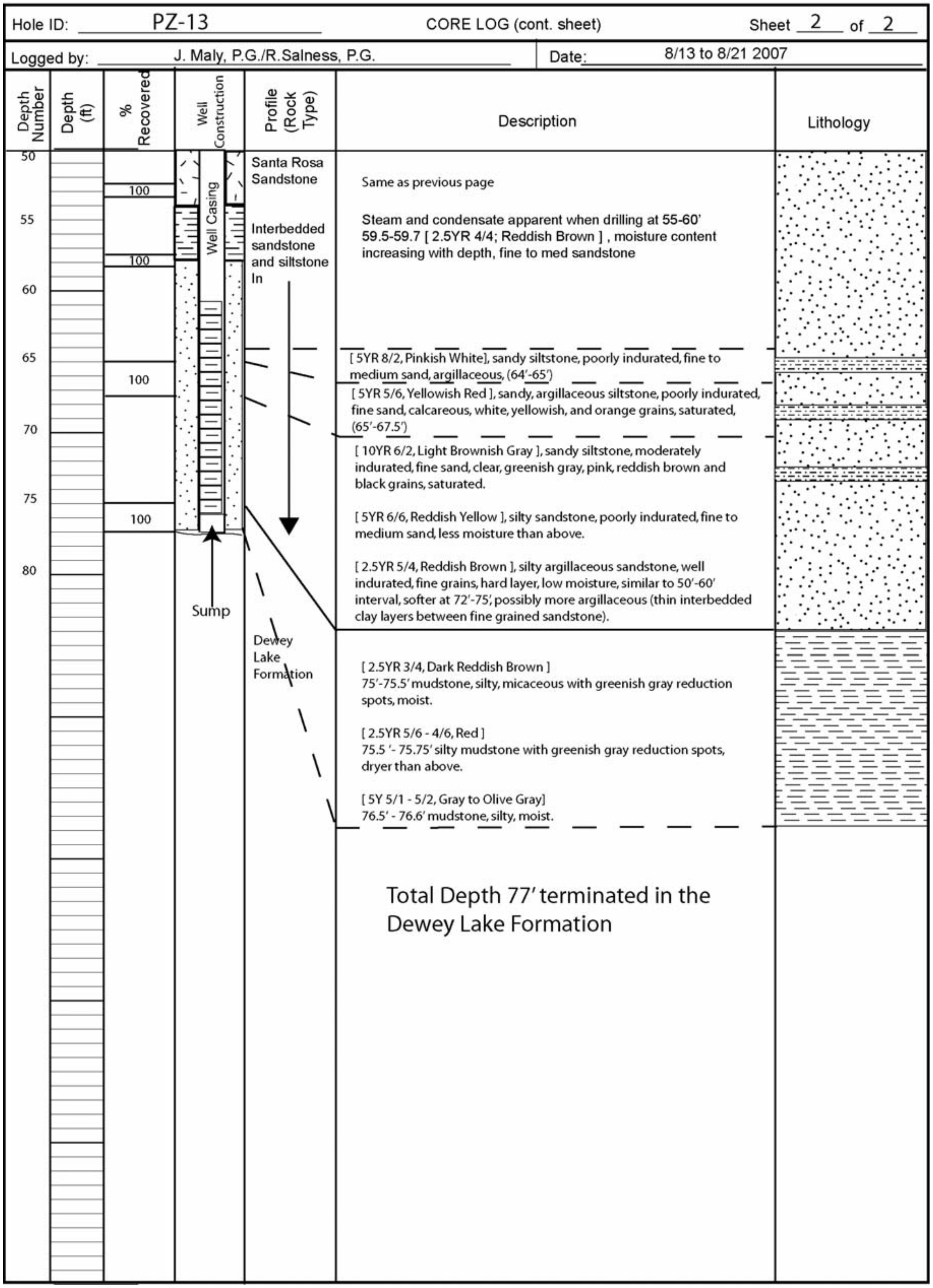
Scale: 1" = 10 '

	Northing	Easting	Elevation
Survey Coordinate: (Ft)			

Comments:

Depth Number	Depth (feet)	% Recovered	Well Construction	Profile (Rock Type)	Description	Lithology
		100	Well Casing	Dune Sand	[5YR 6/4, LT Reddish Brown], sand, fine grained, loose, moist to dry, friable.	
5		80 100		Berino Soil	[2.5YR 5/8 - 4/8; Red], sandy, 3' - 6' calcareous sand, 6' - 6.5' stiff, indurated, low moisture.	
10		80		Mescalero Caliche	[5YR 8/3; Pink], sandy limestone or calcareous sandstone, low moisture, stiff with pebbles and weak laminar structure, at 7.5' to 9', 9'-10' Gatuna inclusions, chert pebbles throughout.	
15		80 100 100		Gatuna Sandstone	[5YR 7/4; Pink], Gatuna Sandstone with Mescalero Caliche overprint, dry to slightly moist, loose to very stiff clasts with caliche, altered manganese oxide throughout, more argillaceous and calcareous than above.	
20 25		100 100 100 100 100			[2.5YR 5/8; Red], Gatuna Sanstone with argillaceous matrix, chert pebbles throughout, root casts coated in manganese oxide, dry, carlcareous, less argillaceous matrix dominated by sand, increased bedding structure with depth, stiff, platy structures, dry, stiff, moderately indurated.	
30		100			[2.5YR 6/6, LT Red], lighter color, more indurated slightly moist.	
35		100 100			[2.5YR 4/8, Red], Carbonate intraclasts incorporated in matrix.	
40 45 50		100 100 <5 100 100 100 100 100		Santa Rosa Sandstone	[2.5YR 4/8, Red], [10YR 7/1, LT Gray], interbedded Red and LT Gray sanstone, dessication cracks with carbonate fill, slickensided surfaces (subhorizontal), dry, moderately indurated. Hard at 35' - 39', 39'-39.2' very hard consolidated, well indurated sandstone, dry [2.5YR 4/4; Reddish Brown] 40'-47' Moderately indurated, moist, platy. Changed over to tricone bit on hollow-stem lead auger limiting samples. Steam and condensate apparent when drilling at 55-60' 59.5-59.7 [2.5YR 4/4; Reddish Brown] , moisture content increasing with depth, fine to med sandstone	

Figure 2-2 - Core Log for PZ-13



Hole ID: PZ-13 CORE LOG (cont. sheet) Sheet 2 of 2

Logged by: J. Maly, P.G./R.Salness, P.G. Date: 8/13 to 8/21 2007

Same as previous page

Steam and condensate apparent when drilling at 55-60'
59.5-59.7 [2.5YR 4/4; Reddish Brown] , moisture content increasing with depth, fine to med sandstone

[5YR 8/2, Pinkish White], sandy siltstone, poorly indurated, fine to medium sand, argillaceous, (64'-65')

[5YR 5/6, Yellowish Red], sandy, argillaceous siltstone, poorly indurated, fine sand, calcareous, white, yellowish, and orange grains, saturated, (65'-67.5')

[10YR 6/2, Light Brownish Gray], sandy siltstone, moderately indurated, fine sand, clear, greenish gray, pink, reddish brown and black grains, saturated.

[5YR 6/6, Reddish Yellow], silty sandstone, poorly indurated, fine to medium sand, less moisture than above.

[2.5YR 5/4, Reddish Brown], silty argillaceous sandstone, well indurated, fine grains, hard layer, low moisture, similar to 50'-60' interval, softer at 72'-75', possibly more argillaceous (thin interbedded clay layers between fine grained sandstone).

[2.5YR 3/4, Dark Reddish Brown]
75'-75.5' mudstone, silty, micaceous with greenish gray reduction spots, moist.

[2.5YR 5/6 - 4/6, Red]
75.5 '- 75.75' silty mudstone with greenish gray reduction spots, dryer than above.

[5Y 5/1 - 5/2, Gray to Olive Gray]
76.5' - 76.6' mudstone, silty, moist.

Total Depth 77' terminated in the Dewey Lake Formation

Figure 2-2 - Core Log for PZ-13 (Continued)

2.2.2 Triassic Santa Rosa Formation

The Santa Rosa is 40 feet thick at this location, from 35 feet bgs to 75 feet bgs. The Santa Rosa and Gatuña were differentiated in this drillhole by a mottled red and light gray sandstone with slickensides as opposed to the basal Gatuña Formation lacking these features and being predominantly a red sandstone at the contact. The Santa Rosa in this piezometer consists of interbedded sandstone of variable color, grain size, induration, cementation, and clay content (Figure 2-2). The formation was well indurated and required air assisted drilling from 47 feet to 64 feet, limiting samples to cuttings. It is presumed this may be due to cementation changes from a carbonate base to a silica base.

The interval from 65 feet to 67.5 feet is a sandy argillaceous siltstone that was saturated during drilling. The saturation in the Santa Rosa was identified during drilling to extend down into a harder siltstone of similar characteristic as the overlying lithology (Figure 2-2). The saturation diminished with depth, but showed increasing induration, and clay content. The underlying Dewey Lake was moist.

Comparatively, the Santa Rosa in PZ-13 is 11 feet thicker than in PZ-8 (29 feet) and PZ-9 (29 feet), indicating a thickening trend to the south, south-east of WIPP. This thickening is suggested by Jones (1978) as a consequence of eastward formational dip and eastward rise in surface topography. The Santa Rosa was deposited in dominantly fluvial environments and lies unconformably on the Dewey Lake.

The Santa Rosa was encountered at approximately the same elevation as in PZ-8, but approximately 2 feet shallower in elevation than PZ-9. Compared to PZ-14 and PZ-15, the Santa Rosa in PZ-13 was encountered 2 feet deeper in elevation than PZ-14 and 7 feet shallower in elevation than in PZ-15, indicating possible localized Permo-Triassic erosional features likely due to fluvial activities.

2.2.3 Miocene-Pleistocene Gatuña Formation

The Gatuña Formation is about 25 feet thick at this location. The Gatuña in PZ-13 is pink (Munsell 5YR 7/4) to red (2.5YR 5/8, 6/6, 4/8) sandstone, with generally fine to medium sand grains. The Gatuña contains bluish-black manganese oxide (MnO) stains throughout. The formation at PZ-13 is friable (very loose sand) to moderately well lithified and platy (Figure 2-2). It is very calcareous in the upper part due to overprint (penetration) of pedogenic processes during early stages of the development of overlying Mescalero caliche (Powers, 2003).

The Gatuña generally increases in thickness to the west in the WIPP area, and the depositional edge of the formation is in the same general area where the Santa Rosa pinches out because of erosion that preceded Gatuña deposition (Powers and Holt, 1993). Gatuña thicknesses in nearby piezometers reflect this trend of increasing thickness to the west. The Gatuña thickness in PZ-8, west of PZ-13, is approximately 30 feet. In PZ-9, northwest of PZ-13, the Gatuña is approximately 30 feet.

The Gatuña in PZ-13 was encountered 3 feet shallower in elevation than in PZ-8 and 2 feet shallower in elevation than in PZ-9. Compared to PZ-14 and PZ-15, the Gatuña in PZ-13 was encountered at the same elevation as in PZ-14, but approximately 4 feet shallower in elevation than in PZ-15, following a possible trend of infilling of an erosional feature.

2.2.4 Pleistocene Mescalero Caliche

The Mescalero caliche is 3.5 feet thick at this location; however, the pedogenic processes that developed the Mescalero have penetrated deeper into the Gatuña Formation as defined by the overprint in Section 2.2.3 and in Figure 2-2. The Mescalero in PZ-13 is pink (5YR 7/4) sandy limestone, or calcareous sandstone with pebbles and weak laminar structure. Basal Gatuña inclusions were encountered at this location from 9 to 10 feet (Figure 2-2). Because the Mescalero is a pedogenic process (soil forming), thicknesses will vary from location to location. In the area of PZ-13, compared to other wells, the thickness varies from 2.5 to 4 feet. 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.

The Mescalero in PZ-13 is approximately 7 feet higher in elevation than in PZ-8 and 5 feet higher in elevation than in PZ-9. Compared to PZ-14 and PZ-15, the Mescalero in PZ-13 was encountered approximately 2 feet higher in elevation than PZ-14 and approximately 5 feet lower in elevation than in PZ-15. This variation is not surprising as the pedogenic process will vary from location to location and generally conforms to underlying topography.

2.2.5 Pleistocene Berino Soil and Surficial Sands

Based on the continuous split spoon sample taken at SNL-13, there is a 4-foot-thick layer of unlithified dune sand and basal argillaceous sand (commonly called the Berino soil, Powers, 2002). The sand is fine grained and calcareous. The Berino soil is not a geologic unit, but defined as a pedogenic unit by local soil scientists (Chugg el al., 1971). The surface sand around WIPP is eolian, with much of it fine to medium grain, moderately well sorted, and poorly indurated. Dunes at the WIPP site are partially stabilized by vegetation (Powers, 2003).

2.3 Geological Data From PZ-14

2.3.1 Permo-Triassic Dewey Lake Formation

The Dewey Lake was encountered in PZ-14 from 70.8 feet to TD at 73 feet (Figure 2-3). In this piezometer interval (70.8 to 73 feet), the Dewey Lake is characterized by a very hard, competent gray and red siltstone, platy, and dry; a red claystone that is unconsolidated with greenish gray reduction spots; and very hard platy red siltstone with greenish gray reduction spots (Figure 2-3). The Dewey Lake in this piezometer was dry at the contact, but damp below. Based on data obtained from the overlying Santa Rosa

Formation (see Section 2.3.2), the TD was based on this depth acting as an aquitard dampening vertical flow of SSW. A well was installed at this location and constructed as depicted in Figure 2-3. The sample obtained from this piezometer did indicate alternating lithologic variations of siltstone and claystone (Figure 2-3).

The Dewey Lake at PZ-14 was encountered 9 feet deeper in elevation than it was in PZ-8, indicating possible erosion during deposition of the overlying Santa Rosa Formation during predominantly fluvial environments. The Dewey Lake was only 0.5 feet shallower in elevation in PZ-14 than in PZ-9, another previously installed piezometer in the area.

2.3.2 Triassic Santa Rosa Formation

The Santa Rosa at this location is 20.8 feet thick, from 50 feet bgs to 70.8 feet bgs, but less than that identified in PZ-13. The Santa Rosa and Gatuña were differentiated in this drill hole, similarly as in PZ-13, by mottled reddish brown and light gray sandstone with slickensides as opposed to the basal Gatuña Formation lacking these features and being predominantly a red sandstone at the contact. Samples for this piezometer were not obtained continuously as the formation was very hard in places and alternative drilling techniques (air assisted) were used. Where samples were not obtained, the geology was assumed to be similar to that identified in PZ-13 where extraordinary effort was made for continuous sampling (Figures 2-2, 2-3).

From the samples obtained for 30 feet bgs to 50 feet bgs the Santa Rosa is identified as interbedded reddish and light gray sandstone to reddish brown very hard siltstone. The sandstone contained carbonate filled dessication cracks, slickensided surfaces, and was poorly to moderately indurated. At 50 feet bgs, the sample indicated a very hard competent siltstone (Figure 2-3). At 50 feet bgs to 70.8 ft bgs, the geology was assumed to be similar to PZ-13 (Figure 2-2).

From 70 to 70.8 feet in PZ-14, the formation was interbedded loose, silty sand and a layer of angular claystone and siltstone fragments. This interval was saturated throughout, but the claystone/siltstone fragments (70.5 to 70.8 feet bgs) appeared to be the primary saturation zone. As discussed in Section 2.3.1, the underlying Dewey Lake was dry, acting as an aquitard.

Comparatively, the Santa Rosa in PZ-14 is thinner than that in PZ-13, PZ-8, and PZ-9. This still correlates with thickening trend to the south-southeast of WIPP as suggested by Jones (1978) as a result of dipping and topography trends. The Santa Rosa in PZ-14 was encountered at approximately nine feet deeper in elevation than PZ-8, and approximately one foot deeper in elevation than PZ-9.

2.3.3 Miocene-Pleistocene Gatuña Formation

The Gatuña is about 23 feet thick at this location. The Gatuña in PZ-14 is pink (5YR 8/4) to red (2.5YR 4/8-5/8) with some light reddish brown (2.5YR 7/4-8/4) interbedded sandstone, with generally fine to medium grains. The Gatuña contains bluish-black MnO stains in the upper and basal portions. Some sections are well lithified and platy. It is very calcareous in the upper portion due to overprinting of the overlying Mescalero caliche. Silica cementation dominates in the basal portion.

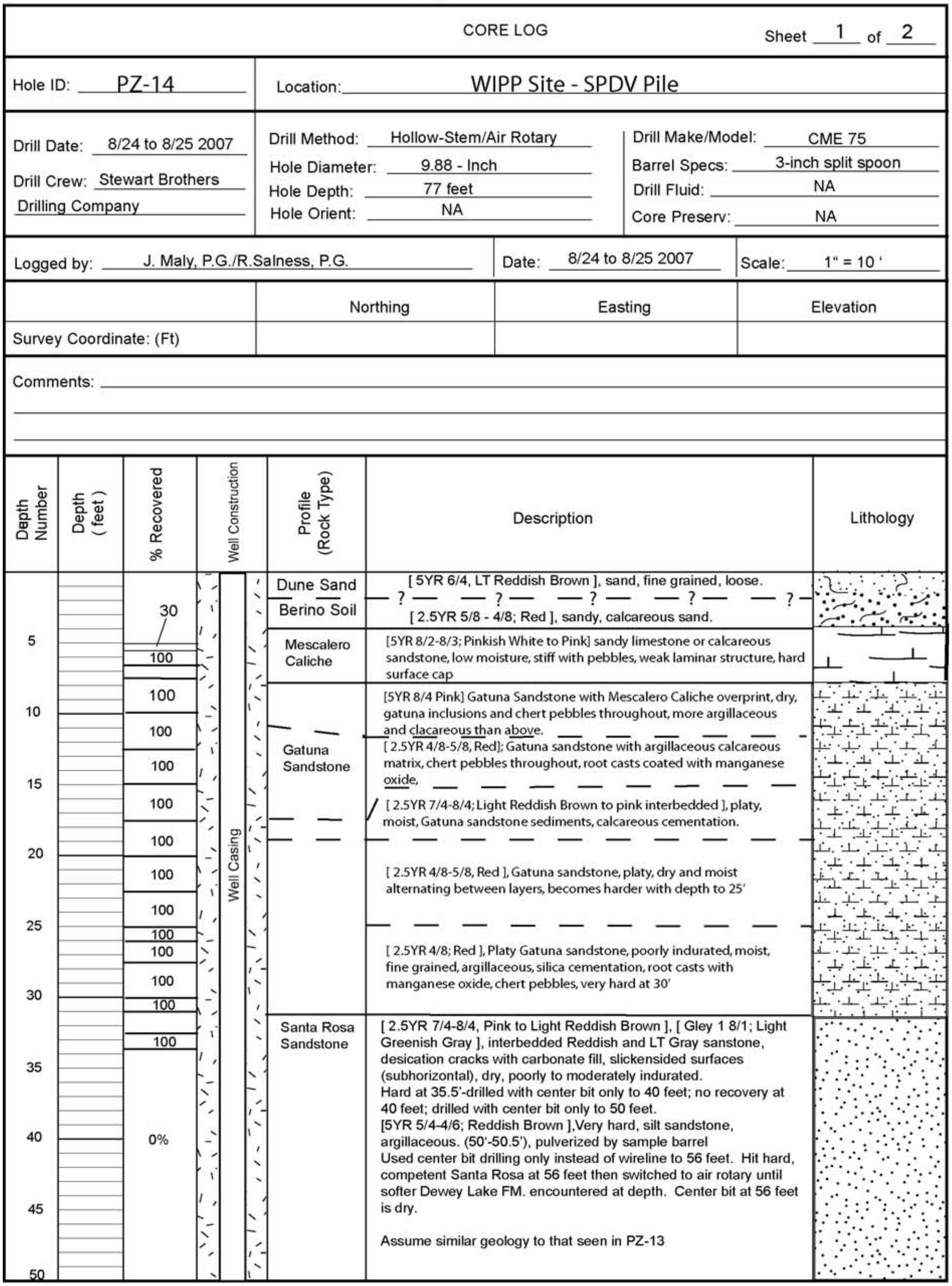
Gatuña thickness in this well compared to other nearby piezometers reflects the trend of westward increasing thickness (Powers and Holt, 1993). The Gatuña in PZ-14 is thinner than in PZ-13, PZ-8, and PZ-9. The Gatuña in PZ-14 was encountered 3 feet shallower in elevation than in PZ-8, and 2 feet shallower in elevation than in PZ-9.

2.3.4 Pleistocene Mescalero Caliche

The Mescalero caliche is 4 feet at this location, although, as described in previous sections, the processes that developed the Mescalero have penetrated deeper into the underlying Gatuña Formation. The Mescalero in PZ-14 is pinkish-white to pink (5YR 8/2-8/3) sandy limestone, with low moisture content containing calcareous pebbles with weak laminar structure. At PZ-14 the Mescalero has a very hard surface cap. The Mescalero in PZ-14 is approximately 4 feet higher in elevation as it is in PZ-8 and 3 feet higher in elevation than it is in PZ-9.

2.3.5 Pleistocene Berino Soil and Surficial Sands

Continuous samples were not taken at PZ-14 until the top of the Mescalero caliche was encountered. Until the depth of 5 feet, center bit drilling with a wireline was used. The Berino soil and surficial sands were described based on auger cuttings, and the contact was estimated based on PZ-13 and PZ-15 sampling (Figure 2-3). The surficial dune sand at this location was the same as other, unlithified, calcareous light reddish brown (5YR 6/4) sand. The Berino soil was characterized as a red (2.5YR 5/8-4/8) loose, fine grained sand.



CORE LOG

Sheet 1 of 2

Hole ID: PZ-14

Location: WIPP Site - SPDV Pile

Drill Date: 8/24 to 8/25 2007

Drill Crew: Stewart Brothers Drilling Company

Drill Method: Hollow-Stem/Air Rotary

Hole Diameter: 9.88 - Inch

Hole Depth: 77 feet

Hole Orient: NA

Drill Make/Model: CME 75

Barrel Specs: 3-inch split spoon

Drill Fluid: NA

Core Preserv: NA

Logged by: J. Maly, P.G./R.Salness, P.G.

Date: 8/24 to 8/25 2007

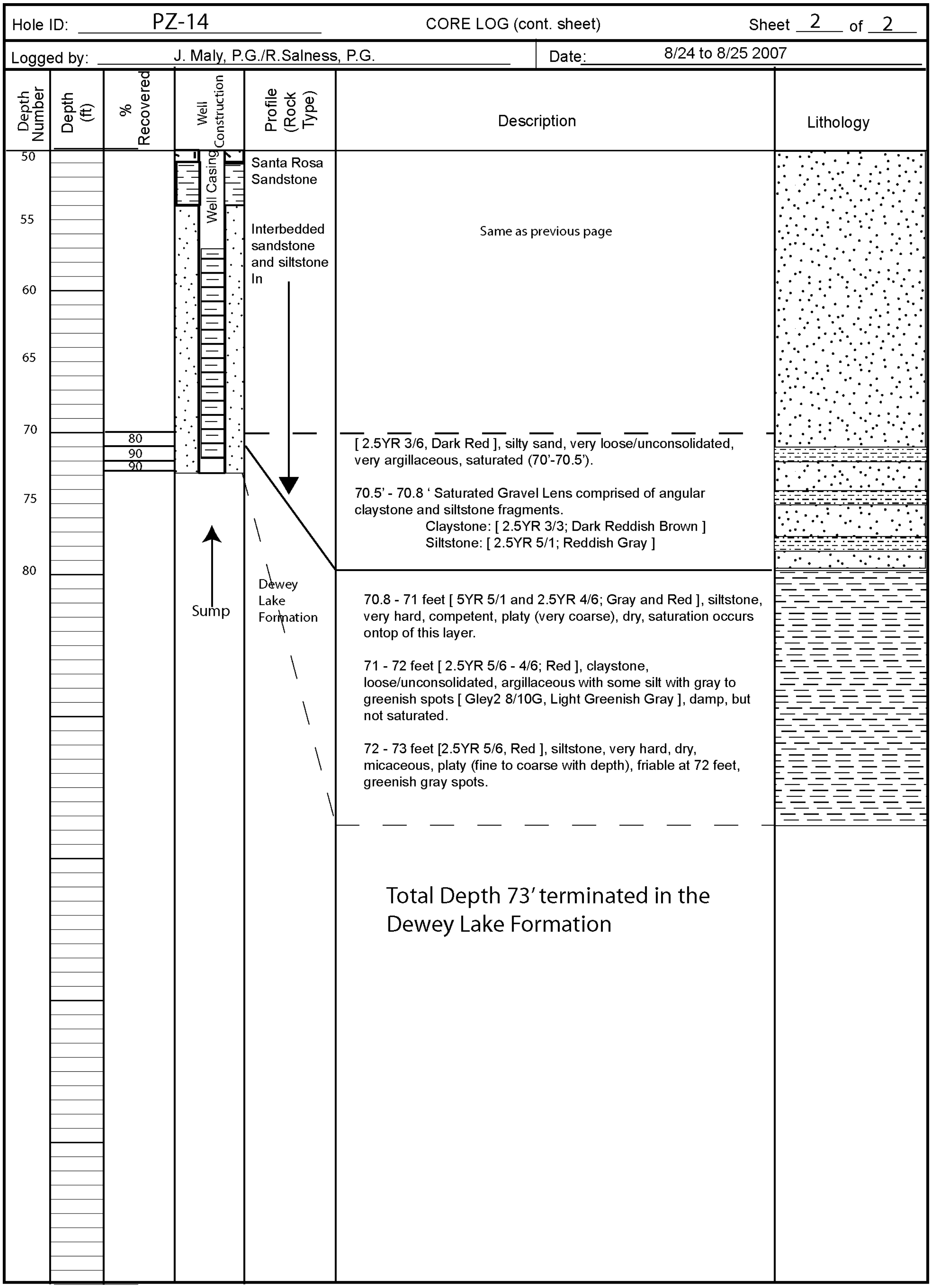
Scale: 1" = 10 '

	Northing	Easting	Elevation
Survey Coordinate: (Ft)			

Comments:

Depth Number	Depth (feet)	% Recovered	Well Construction	Profile (Rock Type)	Description	Lithology
			Well Casing	Dune Sand	[5YR 6/4, LT Reddish Brown], sand, fine grained, loose.	
		30		Berino Soil	[2.5YR 5/8 - 4/8; Red], sandy, calcareous sand.	
5		100		Mescalero Caliche	[5YR 8/2-8/3; Pinkish White to Pink] sandy limestone or calcareous sandstone, low moisture, stiff with pebbles, weak laminar structure, hard surface cap	
10		100 100		Gatuna Sandstone	[5YR 8/4 Pink] Gatuna Sandstone with Mescalero Caliche overprint, dry, gatuna inclusions and chert pebbles throughout, more argillaceous and clacareous than above.	
15		100			[2.5YR 4/8-5/8, Red]; Gatuna sandstone with argillaceous calcareous matrix, chert pebbles throughout, root casts coated with manganese oxide,	
		100			[2.5YR 7/4-8/4; Light Reddish Brown to pink interbedded], platy, moist, Gatuna sandstone sediments, calcareous cementation.	
20		100 100 100			[2.5YR 4/8-5/8, Red], Gatuna sandstone, platy, dry and moist alternating between layers, becomes harder with depth to 25'	
25 30		100 100 100 100			[2.5YR 4/8; Red], Platy Gatuna sandstone, poorly indurated, moist, fine grained, argillaceous, silica cementation, root casts with manganese oxide, chert pebbles, very hard at 30'	
35 40 45 50		100 0%		Santa Rosa Sandstone	[2.5YR 7/4-8/4, Pink to Light Reddish Brown], [Gley 1 8/1; Light Greenish Gray], interbedded Reddish and LT Gray sanstone, desication cracks with carbonate fill, slickensided surfaces (subhorizontal), dry, poorly to moderately indurated. Hard at 35.5'-drilled with center bit only to 40 feet; no recovery at 40 feet; drilled with center bit only to 50 feet. [5YR 5/4-4/6; Reddish Brown],Very hard, silt sandstone, argillaceous. (50'-50.5'), pulverized by sample barrel Used center bit drilling only instead of wireline to 56 feet. Hit hard, competent Santa Rosa at 56 feet then switched to air rotary until softer Dewey Lake FM. encountered at depth. Center bit at 56 feet is dry. Assume similar geology to that seen in PZ-13	

Figure 2-3 - Core Log for PZ-14



Hole ID: PZ-14
CORE LOG (cont. sheet)
Sheet 2 of 2

Logged by: J. Maly, P.G./R.Salness, P.G.
Date: 8/24 to 8/25 2007

Same as previous page

[2.5YR 3/6, Dark Red], silty sand, very loose/unconsolidated, very argillaceous, saturated (70'-70.5').

70.5' - 70.8 ' Saturated Gravel Lens comprised of angular claystone and siltstone fragments.
Claystone: [2.5YR 3/3; Dark Reddish Brown]
Siltstone: [2.5YR 5/1; Reddish Gray]

70.8 - 71 feet [5YR 5/1 and 2.5YR 4/6; Gray and Red], siltstone, very hard, competent, platy (very coarse), dry, saturation occurs ontop of this layer.

71 - 72 feet [2.5YR 5/6 - 4/6; Red], claystone, loose/unconsolidated, argillaceous with some silt with gray to greenish spots [Gley2 8/10G, Light Greenish Gray], damp, but not saturated.

72 - 73 feet [2.5YR 5/6, Red], siltstone, very hard, dry, micaceous, platy (fine to coarse with depth), friable at 72 feet, greenish gray spots.

Total Depth 73' terminated in the Dewey Lake Formation

Figure 2-3 - Core Log for PZ-14 (Continued)

2.4 Geological Data from PZ-15

2.4.1 Triassic Santa Rosa Formation

PZ-15 was terminated in the Santa Rosa Formation where saturation was identified. As such, the Dewey Lake Formation was not encountered in this well.

The top of the Santa Rosa in the well was identified at 51 feet bgs. The entire thickness of this formation is unknown as it was not completely drilled through; however, it is assumed to be thinner than in PZ-13 and PZ-14 due to the thickening westward trend of this formation. The top of the Santa Rosa Formation was saturated.

Drilling was terminated at this point as it was apparent that just deeper, the Santa Rosa Formation dried and became very hard, acting as an aquitard. A piezometer was installed at this depth and constructed as depicted in Figure 2-4.

The 5 feet of Santa Rosa Formation penetrated in this well are characterized as two lithologic variations. The upper portion from 51 to 51.5 feet is described as red (2.5YR 4/8) to light gray (10YR 7/1) interbedded sandstone with dessication cracks that are carbonate filled (Figure 2-4) that becomes softer and sandier with depth. This upper portion was saturated at the top and became dry with depth at the lower very hard portion. The lower section sampled (51.5 to 56 feet) is described as a very hard consolidated dry reddish brown (2.5YR 4/4) sandstone.

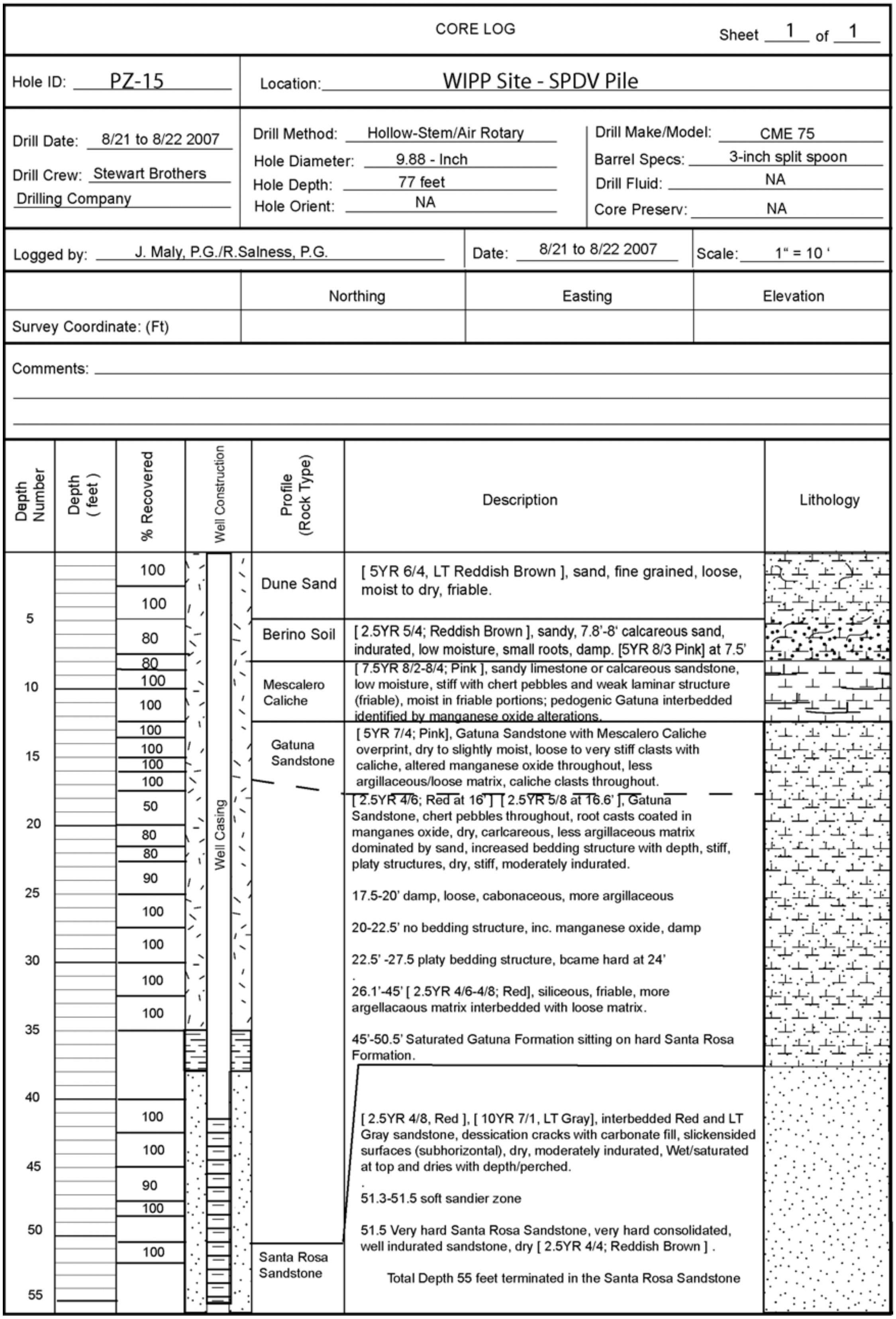
The Santa Rosa in PZ-15 was encountered at approximately 7 feet deeper in elevation than PZ-8, and approximately 5 feet deeper in elevation than PZ-9.

2.4.2 Miocene-Pleistocene Gatuña Formation

The Gatuña Formation is about 39 feet thick at this location, indicating that it gets thicker to the east around the SPDV pile, which is non-typical of the area around the WIPP site. The Gatuña generally thickens to the west in the area of the WIPP site due to erosion of the Santa Rosa Formation, leading to thicker deposition of Gatuña (Powers and Holt, 1993).

The upper 4 feet of Gatuña at this location is pink (5YR 7/4) sandstone with overprint of pedogenic carbonate soil processes that developed the overlying Mescalero caliche. The upper 4 feet are dry to slightly moist, loose to very stiff, with clasts of caliche and altered MnO throughout (Figure 2-4). The lower portion of the Gatuña is predominantly red sandstone with chert pebbles throughout, MnO stained root casts, dominated by sand (less argillaceous) and increased bedding structure with depth (platy).

The Gatuña in PZ-15 was encountered 10 feet shallower in elevation than in PZ-8 and 2 feet shallower in elevation than in PZ-9.



CORE LOG

Sheet 1 of 1

Hole ID: PZ-15

Location: WIPP Site - SPDV Pile

Drill Date: 8/21 to 8/22 2007

Drill Crew: Stewart Brothers Drilling Company

Drill Method: Hollow-Stem/Air Rotary

Hole Diameter: 9.88 - Inch

Hole Depth: 77 feet

Hole Orient: NA

Drill Make/Model: CME 75

Barrel Specs: 3-inch split spoon

Drill Fluid: NA

Core Preserv: NA

Logged by: J. Maly, P.G./R.Salness, P.G.

Date: 8/21 to 8/22 2007

Scale: 1" = 10 '

	Northing	Easting	Elevation
Survey Coordinate: (Ft)			

Comments:

Profile (Rock Type)	Description
Dune Sand	[5YR 6/4, LT Reddish Brown], sand, fine grained, loose, moist to dry, friable.
Berino Soil	[2.5YR 5/4; Reddish Brown], sandy, 7.8'-8' calcareous sand, indurated, low moisture, small roots, damp. [5YR 8/3 Pink] at 7.5'
Mescalero Caliche	[7.5YR 8/2-8/4; Pink], sandy limestone or calcareous sandstone, low moisture, stiff with chert pebbles and weak laminar structure (friable), moist in friable portions; pedogenic Gatuna interbedded identified by manganese oxide alterations.
Gatuna Sandstone	[5YR 7/4; Pink], Gatuna Sandstone with Mescalero Caliche overprint, dry to slightly moist, loose to very stiff clasts with caliche, altered manganese oxide throughout, less argillaceous/loose matrix, caliche clasts throughout. [2.5YR 4/6; Red at 16'] [2.5YR 5/8 at 16.6'], Gatuna Sandstone, chert pebbles throughout, root casts coated in manganes oxide, dry, carlcareous, less argillaceous matrix dominated by sand, increased bedding structure with depth, stiff, platy structures, dry, stiff, moderately indurated. 17.5-20' damp, loose, cabonaceous, more argillaceous 20-22.5' no bedding structure, inc. manganese oxide, damp 22.5' -27.5 platy bedding structure, bcame hard at 24' . 26.1'-45' [2.5YR 4/6-4/8; Red], siliceous, friable, more argellacaous matrix interbedded with loose matrix. 45'-50.5' Saturated Gatuna Formation sitting on hard Santa Rosa Formation.
Santa Rosa Sandstone	[2.5YR 4/8, Red], [10YR 7/1, LT Gray], interbedded Red and LT Gray sandstone, dessication cracks with carbonate fill, slickensided surfaces (subhorizontal), dry, moderately indurated, Wet/saturated at top and dries with depth/perched. . 51.3-51.5 soft sandier zone 51.5 Very hard Santa Rosa Sandstone, very hard consolidated, well indurated sandstone, dry [2.5YR 4/4; Reddish Brown] . Total Depth 55 feet terminated in the Santa Rosa Sandstone

Figure 2-4 - Core Log for PZ-15

2.4.3 Pleistocene Mescalero Caliche

The Mescalero caliche at this location is 4.5 feet thick at this location, although the processes that developed the Mescalero have penetrated deeper into the Gatuña as described in previous sections. The Mescalero in PZ-15 is pink (7.5YR 8/2-8/4) sandy limestone of low moisture content. It has weak laminar structure (friable) with chert pebbles throughout. Some pedogenic Gatuña is interbedded as defined by MnO alterations.

The Mescalero in PZ-14 is approximately 11 feet higher in elevation than it is in PZ-8 and 10 feet higher in elevation than it is in PZ-9.

2.4.4 Pleistocene Berino Soil and Surficial Sands

Based on continuous split spoon samples taken at PZ-15, there is 8 feet of unlithified dune sand and basal argillaceous sand (commonly called Berino soil, Powers, 2002). The sand is fine grained and calcareous. The Berino soil is fined grained, calcareous, and damp with small roots.

2.5 Geologic Significance, Discussion, and Correlation with Other Piezometers

The early SSW piezometers were drilled with air rotary and logged by examination of cuttings from the drill stem. The use of hollow stem augers in PZ-13, PZ-14, and PZ-15 allowed for close examination of the lithology and exactly where saturation occurred. Based on the information from the SPDV pile piezometers, it is clear that no one single lithologic zone can be isolated as being the predominant location for the SSW to reside or flow as the geology is vertically and spatially heterogeneous.

Figure 2-5 presents two cross-section across the site trending west to east (A-A’) and northwest to southeast (B-B'). Cross-section A-A' presents a fairly consistent Gatuña thickness that undulates along the top of the Santa Rosa surface, dipping to the west. The Gatuña begins then to noticeably thicken at the point of PZ-15. The Santa Rosa Formation, on the other hand, is variable in thickness, thinning at the location of PZ-12 and thickening east and west of PZ-12, along the deepening Dewey Lake contact. The top of the Dewey Lake appears to have two structural divides; one at PZ-12 and the other at PZ-8, possibly erosional features. The surface dips sharply to the west and east from PZ-12. At Piezometer C-2507 the slope gradually increases approaching PZ-8, where the Dewey Lake surface dips off towards PZ-13, and presumably at the point of PZ-15; however, this well was completed in the Gatuña Formation. The structural divide at PZ-12 is higher in elevation than that in PZ-8, lending to a steeper slope to the east.

Cross-section B-B’ also presents a fairly consistent Gatuña thickness that mimics the Santa Rosa depositional surface along this trend. The Gatuña gradually dips to the west and east of the PZ-8/PZ-14 area. The Santa Rosa Formation from roughly north to south is relatively consistent in thickness (± 5 feet), with the thicker portion to the south. Structurally, the Santa Rosa dips to the west and east from the PZ-8/PZ-14 area, similar to the Gatuña, and the thickening trends with the deepening Dewey Lake. The top of the Dewey Lake appears to have a structural divide around PZ-8 where the surface dips gently to the west and sharply to the east, possibly an erosional feature.

Figure 2-6 is a wireframe map showing the upper surface of the Dewey Lake Formation for all SSW piezometers that encountered the Dewey Lake contact. Superimposed on this map are the contours of this surface. This figure shows that the surface of the Dewey Lake in the area of interest is comprised of high areas, valleys, and bowls. Sitting on top of this surface is the Santa Rosa Formation. The Dewey Lake has a lower permeability than overlying formations such that vertical flow is impeded, creating a perched water zone at or near the contact.

These characteristics of the Dewey Lake surface (highs, valleys, ridges, bowls) play an important role in defining geological control of SSW accumulation and movement.

Figure 2-7 depicts the same contours of the Dewey Lake surface superimposed onto a shaded relief map of the Dewey Lake surface. This figure highlights the surficial features identified in previous figures and discussed in the above paragraphs. Low areas (depressions) on the Dewey Lake surface are associated with PZ-7, PZ-4, PZ-14, and C-2507. High points are associated with PZ-12, PZ-8, and C-2505/2506. Between these points are ridges, valleys, and plateaus.

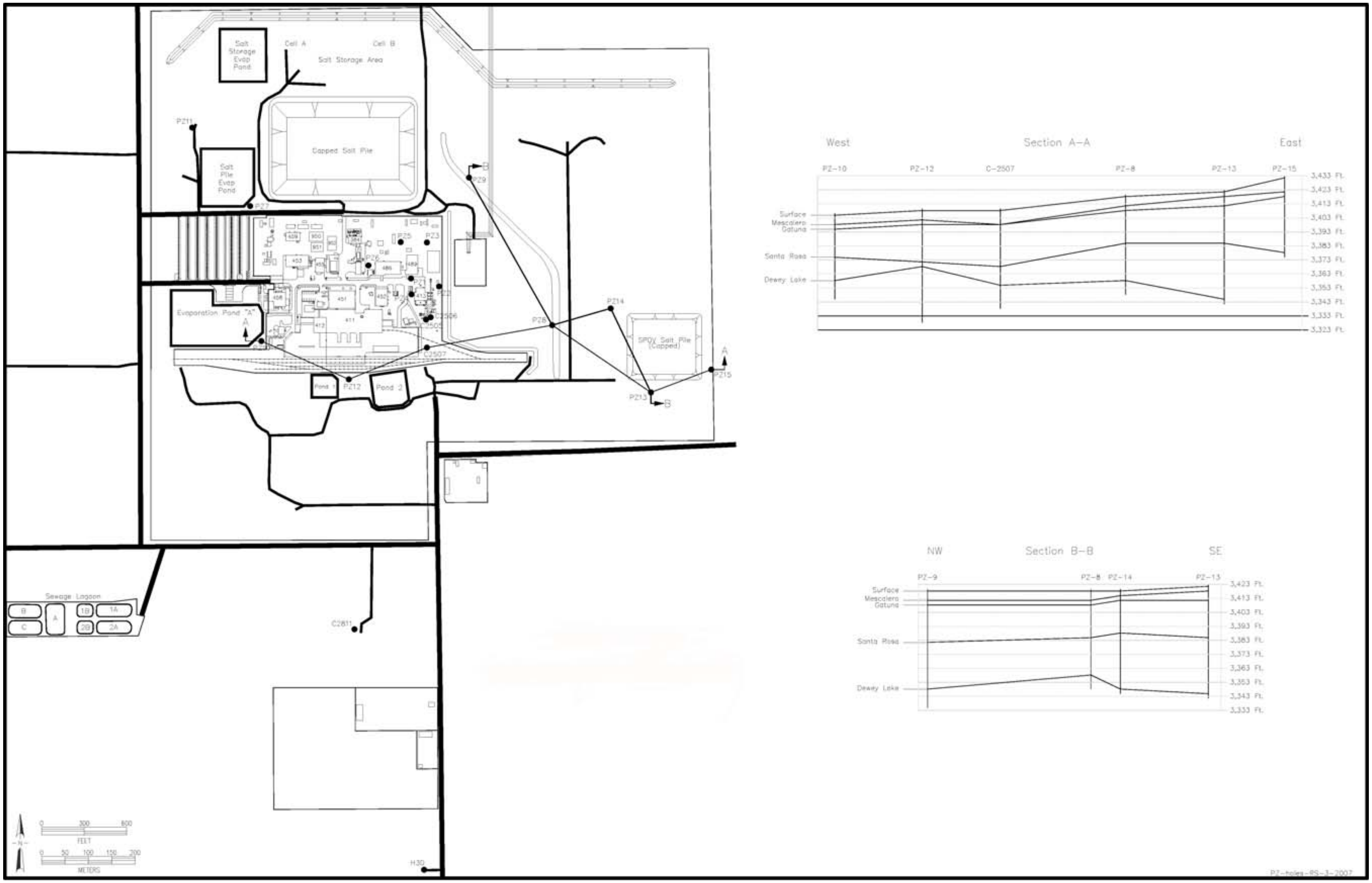


Figure 2-5 - Site Cross-Sections

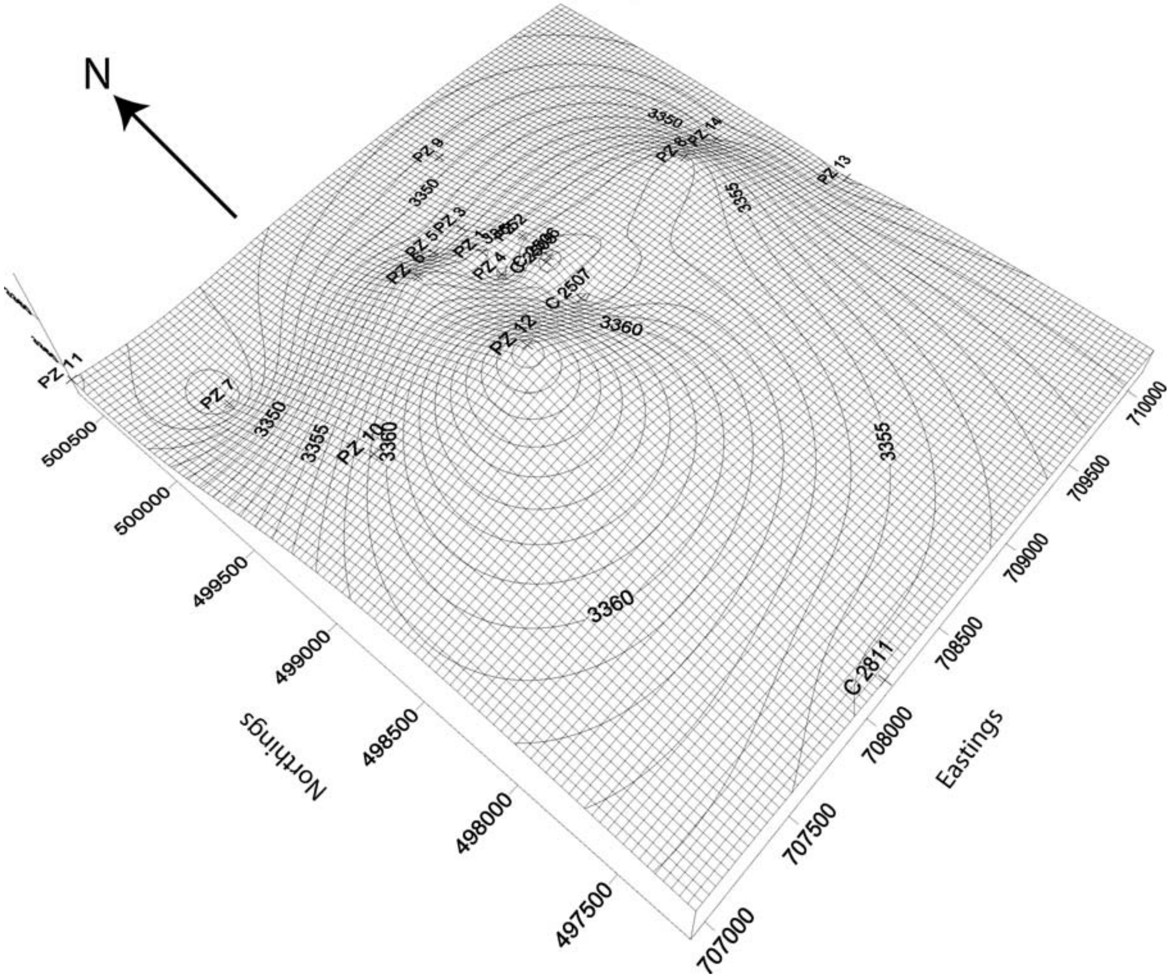


Figure 2-6 - Wireframe Structure Map of Dewey Lake Surface

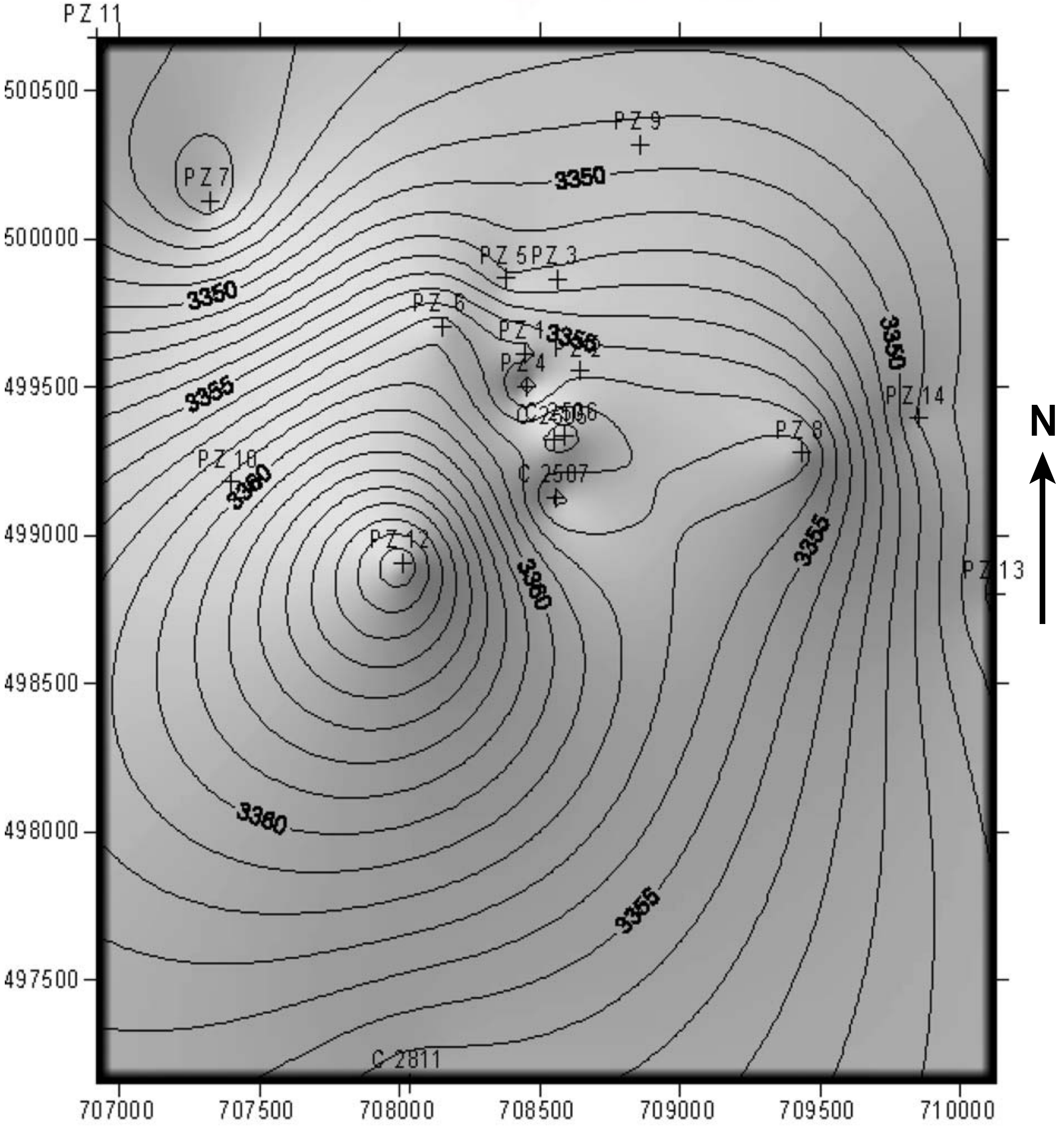


Figure 2-7 - Shaded Relief Structure Map of Dewey Lake Surface

Based of the geologic data obtained from the piezometers around the SPDV pile, there can be some conclusions made at this point:

- The SSW appears to be isolated in different and variable zones around the SPDV pile based on examination of split spoon samples obtained during drilling.
- Structural features of the Santa Rosa/Dewey Lake contact play an important role in accumulation and movement of SSW.
- The stratigraphy overlying the Santa Rosa/Dewey Lake contact is heterogeneous and tortuous.

3.0 HYDROLOGICAL DATA

3.1 Description of Shallow Subsurface Water in the Santa Rosa and Upper Dewey Lake Formations

Shallow Subsurface Water (SSW) was first detected in 1995 when a video inspection of the Exhaust Shaft detected seepage through the shaft liner from approximately 50 to 80 feet bgs. After 1995, a series of hydrologic assessments was undertaken to identify the source and nature of the SSW at WIPP. Sixteen wells were installed around the site to assess the SSW. The SSW was detected in all but one well, PZ-8, which was dry until March 2007. The SSW is a shallow-perched, water-bearing zone that sits on a permeability change at the formational contact between the Santa Rosa Formation and the upper Dewey Lake Formation. The SSW is believed to be entirely anthropogenic in nature, resulting in part from historical natural discharges from locations at WIPP.

In December 2003, the NMED GWQB issued a modified DP-831 indicating that the unlined ponds and stockpiles be lined with a synthetic liner: SSA and SPEP, Ponds 1 and 2, Pond A. Additionally, a new SSE was to be constructed with a synthetically lined base on which infiltration and surface runoff from this pile would be directed to a new evaporation basin. Also included in this modification was a monitoring program that included quarterly water level measurements from all the SSW wells and semiannual sampling of selected SSW wells for TDS, chloride, sulfate, nitrate, chromium, and selenium. This program was implemented in May 2004 and continues to date.

On December 29, 2006, the NMED GWQB issued another DP-831 modification with a condition that the SPDV pile be investigated as a possible source of shallow groundwater. The modification indicated that WIPP should install three monitoring wells adjacent to the SPDV pile. This report has documented the installation of these wells and the data obtained.

Isolated saturated sections were detected in all three piezometer boreholes installed around the SPDV pile, although at differing elevations and lithology. The following sections describe the water levels and chemistry in these wells and a discussion of each as it correlates to the SSW on the WIPP site and the other 16 piezometers.

3.2 Water Levels in Piezometers PZ-13, PZ-14, and PZ-15 and Comparison to WIPP Site Piezometers

In October 2007 a new survey of the piezometer top of casing and ground surface elevation was performed by a New Mexico licensed surveyor to NAD83/NAVD88 datum after the SPDV pile wells were installed. The prior survey performed in the late 1990s was surveyed to a NAD27/NAVD29 datum. All data reported herein are referenced to the 2007 survey. Water level elevations reported prior to this report were to the NAD27/NAVD29 survey.

Water was detected in all three piezometers around the SPDV pile at differing horizons and, in one case, a differing formation. Water saturation in PZ-13 was detected while drilling in the lower Santa Rosa at a depth of 65 feet bgs, an elevation of 3,356 feet above mean sea level (AMSL). Saturation in PZ-13 was confined to a 2.5-foot vertical section of the Santa Rosa characterized by interbedded sandy argillaceous siltstone and sandy siltstone. The water in this boring appeared to be perched upon much harder, consolidated Santa Rosa at the contact with the Dewey Lake Formation. The permeability change of the harder sandstone and underlying Dewey Lake mudstone act as an aquitard perching the water at this elevation. Lithologic intervals above the saturated interval were moist, but not saturated.

Water saturation in PZ-14 was detected while drilling in the lower Santa Rosa at a depth of 70 feet bgs, an elevation of 3,350 feet AMSL. Saturation in this borehole was confined to a thin lense (0.80 foot) of the Santa Rosa, characterized as loose argillaceous sand and a section of interbedded angular claystone and sandstone fragments/pebbles. The saturated lens was sitting upon the contact with the Dewey Lake Formation (mudstone). This permeability contrast allowed the perching of water at this depth as the Dewey Lake acted as an aquitard. Samples were not obtained above this interval as air assisted drilling was employed; however, steam or other indicators of moisture were not apparent.

Water saturation in PZ-15 was detected while drilling in the lower Gatuña Formation at a depth of 45 to 55.5 feet bgs, an elevation of 3,385 feet AMSL. Saturation was in the lower Gatuña, where it became more friable, sitting on the Santa Rosa contact. The upper Santa Rosa Formation in this borehole is very hard at 51.5 feet bgs (3,379 feet AMSL) acting as an aquitard and perching the water at this interval.

Geologically, the underlying formations are very heterogeneous between piezometers (spatially) as well as between formations and within formations (vertically). Heterogeneity in the horizontal and vertical directions is significant as characterized by careful and mostly continuous sampling while drilling. This heterogeneity leads to preferential and tortuous flow paths. The detected saturation, as discussed above, occurred in different horizons of variable thickness and lithologic structure, lending to preferential flow and tortuosity.

The heterogeneity and tortuous flow affects the ability for saturated lenses to develop or connect with one another. An attempt was made to sample piezometers PZ-8, PZ-13, PZ-14, and PZ-15 on October 10, 2007, by low-flow sampling methods using a small diameter submersible pump. Typical sustained flow rates during sampling for the SSW piezometers at WIPP range from 400 milliliters per minute (mpm) to 1,500 mpm while keeping water levels stable and drawdown to a minimum. This could only be achieved for PZ-13, which pumped at an average rate of 1,050 mpm, but was pumped dry as the sample was obtained. Piezometers PZ-8, PZ-14, and PZ-15 could not sustain enough flow to measure before pumping dry. These wells were later sampled using a Teflon™ hand bailer (see Section 2.3). This indicates not only low permeability in the formation but, due to the small saturated lenses, a low volume of SSW in storage around the SPDV pile.

Figure 3-1 is a potentiometric surface map of the SSW at the WIPP site inclusive of the wells at the SPDV pile based on the water levels presented in Table 3-1, and is superimposed on a shaded relief structure map of the Dewey Lake surface. Well H-3d (Figure 1-2) was converted to a shallow monitoring well during the *WIPP Fiscal Year 2005 Plugging, Abandonment, and Well Reconfiguration Program* (DOE/WIPP 05-3326) and is not included in this map. Water levels in Well H-3d are monitored quarterly and to date there has been no SSW impact at this location. Therefore, the southern extent of SSW at the WIPP likely lies between PZ-12 and H-3d. Figure 3-1 does not include PZ-15, as it was completed in the Gatuña Formation.

Based on Figure 3-1, it appears that the surface of the Dewey Lake has an influence on the potentiometric surface and flow system of the SSW. High points in the contact, such as at PC-7, appear to create a radial flow, when water from the SPEP was contributing to infiltration. A ridge aligned with PX-5 and south to C-2507 tends to direct water east and west. Low points in the surface structure are variable depending upon how much water has perched in these areas. The primary flow direction is south.

The water around the SPDV pile is defined by PZ-13, PZ-14, and PZ-15. Water levels for these wells were obtained approximately four months after they were installed. As discussed in previous sections, PZ-15 was completed in a different geologic horizon than PZ-13 and PZ-14, and is reflected in the differing water level elevations (Table 3-1). Hydrographs compiled for the WIPP site piezometers indicate an interconnection by having similar time series responses in water elevation fluctuation. Not enough data have been accumulated to determine connectivity between SPDV pile piezometers or between site piezometers and SPDV pile piezometers. However, based on the small lenses with water identified during drilling, lack of storage identified during sampling and low permeability, vertical and spatial heterogeneity, and tortuous media, the tentative conclusion at this point is that the water identified in PZ-13, PZ-14, and PZ-15 are all isolated from each other. Some of this can be seen with chemical differences (Section 3.3).

Table 3-1 - Measured Water Elevations
December 5, 2007

Well I.D.	Top of Casing Elevation	Water Level	Water Level Elevation
PZ-1	3,414.92	39.98	3,374.94
PZ-2	3,414.99	40.09	3,374.90
PZ-3	3,417.76	41.62	3,376.14
PZ-4	3,413.65	43.24	3,370.41
PZ-5	3,416.88	39.95	3,376.92
PZ-6	3,414.96	40.98	3,373.98
PZ-7	3,415.47	35.3	3,380.17
PZ-8	3,419.83	63.49	3,356.34
PZ-9	3,422.73	56.2	3,366.53
PZ-10	3,407.37	33.51	3,373.86
PZ-11	3,420.41	43.28	3,377.13
PZ-12	3,410.55	48.82	3,361.73
PZ-13	3,423.88	63.95	3,359.93
PZ-14	3,422.22	66.6	3,355.62
PZ-15	3,432.50	45.28	3,387.22
C-2505	3,414.57	42.91	3,371.66
C-2506	3,414.48	42.33	3,372.15
C-2507	3,411.54	42.8	3,368.74
C-2811	3,400.47	51.34	3,349.13

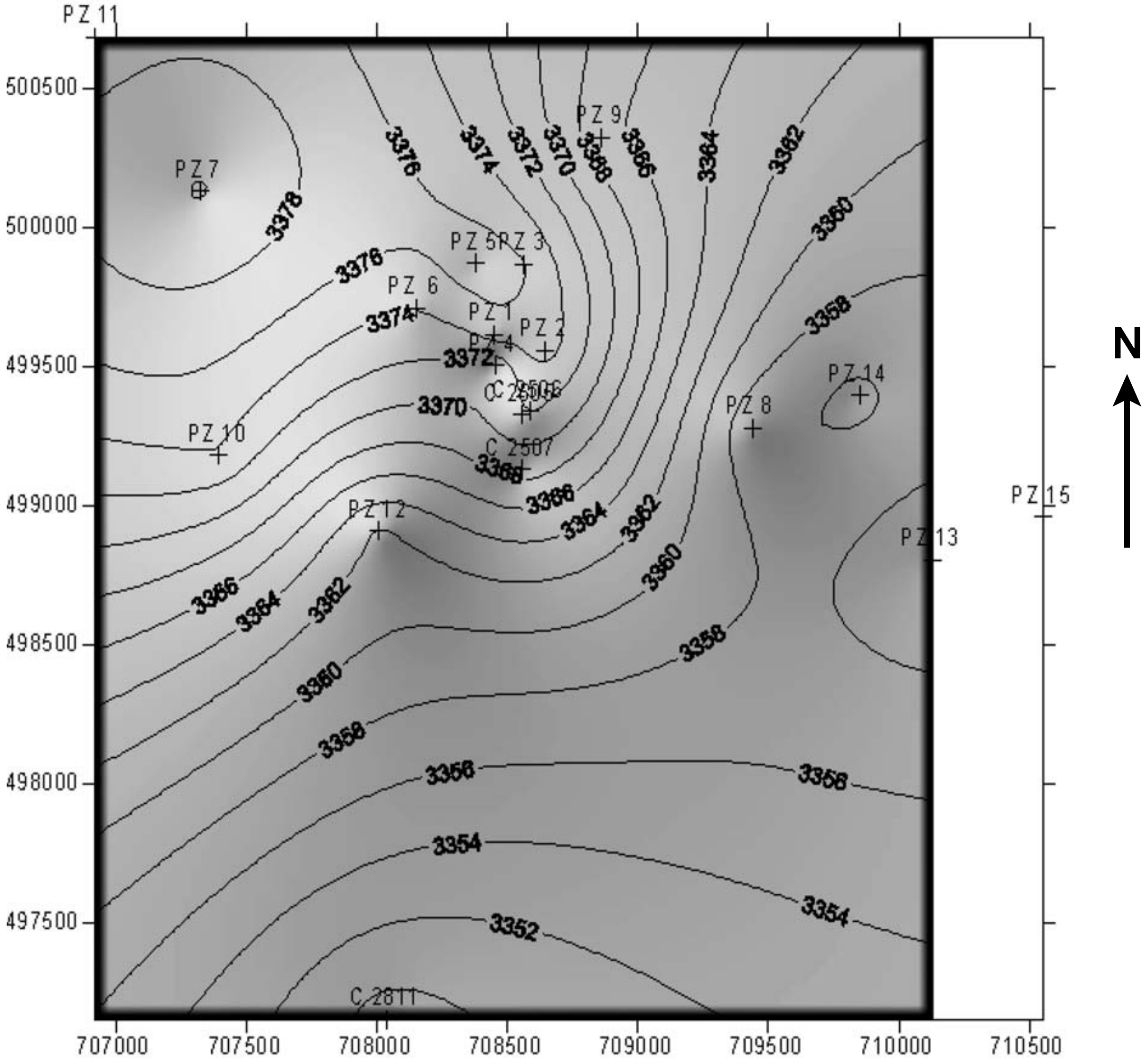


Figure 3-1 - Potentiometric Surface Map Superimposed on Dewey Lake Surface

Overall, the water levels in the WIPP piezometers are rising in all wells, although at differing rates. One well, PZ-9, has been decreasing in elevation since March of 2005. This decreasing water level may be the first sign that lining the salt pile is having an effect on the SSW elevation. The decreasing water levels at PZ-9 began shortly after the conveyance ditches around the Salt Storage Area were lined. This conclusion is preliminary, it is too soon to tell what impact the liner systems at the site have had on water levels in the piezometers.

3.3 Water Quality in Piezometers PZ-13, PZ-14, and PZ-15 and Comparison to WIPP Site Piezometers

SSW samples have been obtained semiannually from the site piezometers as part of DP-831 since 2004. The quarterly sampling event for DP-831 was performed in October 2007, and included the three new piezometers. Since the piezometers around the SPDV pile were new, parameters beyond those required by the permit were analyzed to characterize the water (Table 3-2).

Low-flow sampling techniques are typically employed to sample the piezometers at WIPP. This involves using a small diameter submersible pump with typical sustained flow rates during sampling of 400 mpm to 1500 mpm, while keeping water levels stable and drawdown to a minimum. The water is field analyzed for temperature, conductivity, and pH until these parameters stabilize, then a laboratory sample is obtained. This could only be achieved for PZ-13, which pumped at an average rate of 1,050 mpm, but was pumped dry as the sample was obtained. Piezometers PZ-8, PZ-14, and PZ-15 could not sustain enough flow to measure before pumping dry. Piezometers PZ-8, PZ-14, and PZ-15 were pumped dry on October 10, 2007, and allowed to recover until October 15, 2007, where they were sampled using a Teflon™ hand bailer. PZ-8 was installed in 1997 and remained dry until this year. This was the first time this well was sampled. Results for wells PZ-8, PZ-14, and PZ-15 are presented in Table 3-2. Table 3-3 presents results for the DP-831 required parameters for all the sampled WIPP SSW piezometers.

Table 3-2 presents three different geochemical zones:

1.0 PZ-15, carbonate-based alkalinity. PZ-15 is near is a topographic depression to the east. During heavy rainfall this depression holds water for a period of time; enough such that cattle congregate to drink. The alkalinity in PZ-15 is predominantly carbonate based while the others are bicarbonate based. This is due to the infiltration of rainwater through the upper Mescalero caliche and higher surficial calcium carbonate dissolution.

2.0 PZ-13 and PZ-14, bicarbonate-based alkalinity. These wells may be affected by recharge from the SPDV pile more than rainwater going through caliche at PZ-15. Alkalinity is likely due to the dissolution of sulfates (gypsum and anhydrite) in the SPDV pile. As discussed in Section 1.1, the SPDV pile was used to store mined tailings interspersed with soil, rock, and debris from the construction of the shafts. All formations to the depth of the shafts were mined; therefore, minerals such as gypsum ($CaSO_4 \bullet 2H_20$), anhydrite ($CaSO_4$), halite (NaCl), sylvite (KCl), carnallite ($KMgCl_3 \bullet 6H_20$), and soda niter ($NaNO_3$) associated with gypsum and halite were included in the SPDV pile cuttings and explain the chemical differentiation.

Dissolved potassium is significantly higher in PZ-13 and PZ-14 than the other two piezometers, which can likely be attributed to the dissolution of sylvite and carnallite (potash salts). Sulfate concentrations in PZ-13 and PZ-14 are significantly higher and can be attributed to dissolution of anhydrite and gypsum found in formations above the Salado Formation.

3.0 PZ-8, low TDS, low potassium and sulfate, intermediate sodium, and chloride. Dissolved sodium and chloride can be associated with the dissolution of halite, predominantly found in the Salado Formation. While halite is almost exclusive to the salt pile, the SPDV pile also contains halite. Thus, sodium and chloride concentrations are greater in PZ-13 and PZ-14 than in PZ-8, due to SPDV pile proximity. Lacking potassium and sulfate, it is difficult to conclude the source of water in PZ-8 based on a single sample.

To summarize, the document titled *Exhaust Shaft: Phase III Hydraulic Assessment Data Report October 1997 - October 1998* (DOE-WIPP Draft 2302) presents analytical data from piezometers PZ-1 through PZ-12, C-2505, C-2506, and C-2507 for these years. In it the concentration for sulfate range was 404 - 2910 mg/L, nitrate was 4.2 - 46.6 mg/L, sodium 183 - 50,900 mg/L, potassium 3.7 - 356 mg/L, and calcium 270 - 4580 mg/L. Table 3-2 fingerprints SPDV pile PZ-13 and PZ-14 by high potassium concentration, indicating a different source of groundwater than the wells within the operational area.

Table 3-2 - SPDV Piezometer Water Quality

Parameter	ID/Sample Date	PZ-8/ 10-15-07	PZ-13/ 10-10-07	PZ-14/ 10-15-07	PZ-15/ 10-15-07*
Hydroxide Alk. (mg/L)		<1.00	<1.00	<1.00	<1.00
Carbonate Alk. (mg/L)		<1.00	<1.00	<1.00	1100
Bicarbonate Alk. (mg/L)		150	144	146	<4.00
Total Alk. (mg/L)		150	144	146	550
Dissolved Ca (mg/L)		1530	2220	1060	14.2
Dissolved K (mg/L)		17.2	618	649	7.15
Dissolved Mg (mg/L)		1260	1250	696	10.1
Dissolved Na (mg/L)		842	86100	41500	779
Specific Conductance (µMHOs/cm)		18100	366000	184000	3380
Chloride (mg/L)		7440	150000	71500	764
Fluoride (mg/L)		<1.00	22.2	<1.00	9.01
Sulfate (mg/L)		500	2670	2140	169
Nitrate (mg/L)		0.677	12.4	1.41	2.97
pH (s.u.)		7.26	6.09	6.74	8.66

Table 3-2 - SPDV Piezometer Water Quality

Parameter	ID/Sample Date	PZ-8/ 10-15-07	PZ-13/ 10-10-07	PZ-14/ 10-15-07	PZ-15/ 10-15-07*
TDS (mg/L)		15000	245500	106000	2060
Diss. Silver (mg/L)		<0.00200	<0.00200	<0.00200	<0.00200
Diss. Arsenic (mg/L)		<0.0100	<0.0100	<0.0100	<0.0100
Diss. Barium (mg/L)		0.251	0.116	0.298	0.051
Diss Cadmium (mg/L)		<0.00100	<0.00100	<0.00100	<0.00100
Diss. Chromium (mg/L)		<0.00500	<0.00500	<0.00500	<0.00500
Diss. Mercury (mg/L)		<0.000200	<0.000200	<0.000200	<0.000200
Diss. Lead (mg/L)		<0.0100	0.25	<0.0100	<0.0100
Diss. Selenium (mg/L)		0.039	<0.0100	<0.0100	0.022

(*) PZ-15 installed in the Gatuña Formation rather than Santa Rosa/Upper Dewey Lake contact

Table 3-3 - Water Quality Results for All WIPP Piezometers

	Water Level Monitoring (Ft AMSL)		Field Parameters October 2007			General Chemistry Parameters					Trace Metals	
Monitoring Site	**39343**	**39420**	**pH (SU)**	**Temp. (^{0}C)**	**Specific Conductivity @25 ^{0}C (µS/cm)**	**Sample Date**	**Nitrate (mg/L)**	**Sulfate (mg/L)**	**Chloride (mg/L)**	**TDS (mg/L)**	**Selenium (mg/L)**	**Chromium (mg/L)**
PZ-1	3373.26	3374.94	6.34	22.6	113500	39363	<1.00	2820	**83200**	**99500**	<0.100	<0.0250
PZ-2	3372.99	3374.9	NS	NS	NS	NS	NA	NA	NA	NA	NA	NA
PZ-3	3374.29	3376.14	NS	NS	NS	NS	NA	NA	NA	NA	NA	NA
PZ-4	3368.61	3370.41	NS	NS	NS	NS	NA	NA	NA	NA	NA	NA
PZ-5	3375.2	3376.93	6.8	21.2	37500	39363	<1.00	1880	19400	28700	0.071	<0.00500
PZ-6	3372.17	3373.98	6.3	21.4	128000	39363	<1.00	3080	8100	105000	<0.100	<0.0250
PZ-7	3378.47	3380.17	6.44	22.2	78700	39362	<1.00	2660	45600	65000	0.064	<0.00500
PZ-8	3355.59	3356.34	Bailed	Bailed	Bailed	39369	0.677	500	7440	15000	0.039	<0.00500
PZ-9	3364.93	3366.53	6.22	20	155000	39363	<200	4720	116000	144000	<0.0200	<0.00500
PZ-10	3372.29	3373.86	7.08	22.3	1450	39362	<1.00	211	186	968	<0.0200	<0.00500
PZ-11	3375.52	3377.13	6.34	23.4	127100	39362	<1.00	2970	94400	108000	<0.0200	<0.00500
PZ-12	3359.72	3361.73	6.85	20.7	10760	39362	<1.00	958	4310	6200	0.026	<0.00500
PZ-13	3359.91	3359.93	6.09	22.8	>200000	39364	12.4	2670	150000	245500	<0.100	<0.00500
PZ-14	3355.31	3355.62	Bailed	Bailed	Bailed	39369	1.41	2140	71500	106000	<0.0100	<0.00500
PZ-15*****	3387.19	3387.22	Bailed	Bailed	Bailed	39369	2.97	169	764	2060	0.022	<0.00500
C-2811	3347.07	3349.13	7.05	20.3	6400	39362	<1.00	635	2980	3860	0.051	<0.00500
C-2505	3369.96	3371.66	NS	NS	NS	NS	NA	NA	NA	NA	NA	NA
C-2506	3370.36	3372.15	NS	NS	NS	NS	NA	NA	NA	NA	NA	NA
C-2507	3367.03	3368.74	6.88	20	9410	39363	<1.00	1220	3500	5540	0.055	0.007

4.0 CONCLUSIONS

Piezometers PZ-13, PZ-14, and PZ-15 indicated saturated sections in all three locations at differing horizons and, in one case, a differing formation. Based on the geologic data obtained the SSW appears to be isolated in different and variable zones around the SPDV pile based on examination of split spoon samples obtained during drilling. Structural features of the Santa Rosa/Dewey Lake contact play an important role in accumulation and movement of SSW and the stratigraphy overlying the Santa Rosa/Dewey Lake contact is heterogeneous and tortuous. The heterogeneity and tortuosity leads to preferential flow and a vertical dampening affect. The heterogeneity, small saturated lenses, and tortuous flow affects the ability for flow to readily occur in the unsaturated zone around the SPDV pile.

Overall the water levels in the WIPP piezometers are rising, although at differing rates. One well, PZ-9, has been decreasing in elevation since March of 2005. The decreasing water levels at PZ-9 began shortly after the conveyance ditches around the Salt Storage Area were lined. It is too soon to consider this a cause and effect, or to tell other impacts of the liner systems at the site on water levels in the piezometers.

Three geochemical zones have been identified based on the data obtained from PZ-13, PZ-14, PZ-15, and PZ-8. One being associated with PZ-15, the second associated with PZ-13 and PZ-14, and the third associated with PZ-8. PZ-13 and PZ-14 are believed to be associated with the SPDV pile. The data are inconclusive with regard to PZ-8. Water detected in PZ-15 is believed to be associated with shallow infiltration from a topographic depression east of the SPDV pile.

5.0 REFERENCES

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

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.

Daniel B. Stephens & Associates, 1996, *Characterization of the Site Preliminary Design Validation Salt Pile,* UN001325.

Daniel B. Stephens & Associates, 2003, *Water Budget Analysis of Shallow Subsurface Water at the Waste Isolation Pilot Plant*, UN001304.

Jones, C. L., 1978, *Test Drilling for Potash Resources: Waste Isolation Pilot Plant Site, Eddy County, New Mexico.*

Powers, D. W., 1997, *Geology of piezometer holes to investigate shallow water sources under the Waste Isolation Pilot Plant, in Intera, 1997, Exhaust Shaft Hydraulic Assessment Data Report*, DOE/WIPP 97-2219, U.S. Department of Energy, Carlsbad, NM.

Powers, D. W., 2003, *Basic Data Report for Drillhole C-2811 (Waste Isolation Pilot Plant),* DOE/WIPP 02-3223, U.S. Department of Energy, Carlsbad, NM.

Powers, D. W., and Holt, R. M., 1993, *The Upper Cenozoic Gatuña Formation of Southeastern New Mexico.*

Sergent, Hauskins, & Beckwith, 1979, *Phase III Waste Isolation Pilot Plant Subsurface Exploration & Laboratory Testing*.