DOCKET NO: A-98-49
Item: II-B3-12 B

INSPECTION REPORT

INSPECTION No. EPA-WIPP-6.00-21 (Monitoring)
OF THE
WASTE ISOLATION PILOT PLANT
June 21-22, 2000

U. S. ENVIRONMENTAL PROTECTION AGENCY
Office of Radiation and Indoor Air
Center for Federal Regulation
1200 Pennsylvania Avenue, NW
Washington, DC 20460

August 2000

Table of Contents

<u>Attachments</u>

1.0 Executive Summary

The U.S. Environmental Protection Agency (EPA) conducted an inspection of the Department of Energy's (DOE) Waste Isolation Pilot Plant (WIPP) on June 21-22, 2000, as part of our continuing WIPP oversight program. The purpose of this inspection was to verify that DOE is monitoring the ten parameters listed in the Compliance Certification Application (CCA), Volume 1, Section 7.0, in particular Table 7-7 (See Table 1).

The inspection examined implementation of monitoring for geomechanical, hydrological, waste activity, drilling related, and subsidence parameters. The inspectors toured locations where measurements are taken, reviewed parameter databases, and reviewed documents and procedures directing these monitoring activities.

The inspectors found that DOE, through its contractor Westinghouse, effectively implemented the monitoring program at WIPP. The inspection team also confirmed that DOE's program requires reporting the results of these various monitoring programs on an annual basis, as committed in the CCA.

2.0 Background

Section 42(a) of 40 CFR Part 194 requires DOE to "conduct an analysis of the effects of disposal system parameters on the containment of waste in the disposal system." The results of these analyses must be included in the CCA and are to be used to develop pre-closure and post-closure monitoring requirements.

Volume 1, Section 7.0, of the CCA documents DOE analysis of monitoring. Table 7-7 of the CCA (see Attachment D.6, COB 194-1-2000) lists the ten parameters that DOE determined may impact the disposal system. These parameters are grouped into major categories and listed in Table 1.

Table 1 - Monitored Parameters	
Geomechanical Parameters- -Creep closure, -Extent of deformation, -Initiation of brittle deformation, and -Displacement of deformation features.	**Waste Activity Parameter-** -Waste Activity **Subsidence Parameter-** -Subsidence measurements
Hydrological Parameters- -Culebra groundwater composition and -Change in Culebra groundwater flow direction.	**Drilling Related Parameters-** -Drilling rate and -The probability of encountering a Castile brine reservoir.

We accepted these ten monitoring parameters in the certification issued on May 18, 1998. This inspection was performed under authority of 40 CFR 194.21 to verify the continued effectiveness of the parameter monitoring program at WIPP.

3.0 Scope

Inspection activities included an examination of monitoring and sampling equipment both on and off site, and in the underground. We also reviewed sampling procedures and measurement techniques.

4.0 Inspection Team, Observers, and Participants

The inspection team consisted of two representatives of the EPA Administrator. Observers from the Environmental Evaluation Group (EEG), Jim Kenney and Bill Bartlett, were also present.

Inspection Team Member	Position	Affiliation
Chuck Byrum	Inspection Team Leader	EPA
Nick Stone	Inspector	EPA

Numerous DOE staff and contractors participated in the inspection.

DOE/Contractor Participate	Position	Affiliation
George Basabilvazo		DOE/CAO
Richard Farrell		DOE/CAO
Stan Patchet	General Engineering	WID
Jack Gilbert	Mine Manager	DOE
Ron Richardson	ES&H	WID
Ken Mikus	Waste Ops	WID
Stewart Jones	ES&H	WID
Rey Carrasco	Geo. Engr.	WID
Dave Speed		WID
Tim Kerr		Garwin

WID = Westinghouse CAO = Carlsbad Area Office ES&H = Environmental Safety and Health

The inspection began on Wednesday, June 21, 2000, with a presentation by DOE/CAO and WID about the present status of the WIPP program. Dave Speed discussed the present status of the WWIS computer system (Attachment D.6, COB 194-3-2000).

The inspection team reviewed various activities to verify effective implementation of the plans and procedures. Inspectors observed a demonstration of the WIPP Waste Information System (WWIS), which is used to track the waste shipped from TRU waste sites. Inspectors also reviewed the Delaware Basin Drilling Surveillance program, Groundwater Monitoring Program, and the Ground Control Monitoring program.

The DOE/WID year 2000 Environmental Monitoring Sampling Schedule is in Attachment D.6 (COB 194-AA-2000).

5.0 Performance of the Inspection

EPA inspectors reviewed three fundamental areas to verify continued implementation of the DOE monitoring program during the pre-closure phase: 1) written plans and procedures, 2) quality assurance procedures and records, and 3) results of the monitoring program in the form of raw data, intermediate reports, and final annual reports, if appropriate. The inspection checklist in Attachment A.2 provides details of inspection activities.

5.1 Monitoring of Geomechanical Parameters

DOE committed to measure four geomechanical parameters in the CCA: creep closure, extent of deformation, initiation of brittle deformation, and displacement of deformation features. WIPP has four programs that supply information for these four parameters: the geomechanical monitoring program, the geosciences program, the ground control program, and the rock mechanics program. These programs are documented in the "Geotechnical Engineering Program Plan" (WP 7-1, Attachment D.1, COB 194-AI-2000).

The results of the Geotechnical Engineering Program are documented in the Geotechnical Analysis Report for July 1997 - June 1998 (Attachment D.1,COB 194-A-2000).

Inspectors toured and reviewed underground instrumentation, the computer database, and field data sheets used to record raw measurement data (Attachment D.1, COB 194-T-2000). They also team examined the input of data into the computer database and examined the output QA checkprints (Attachment D.1, COB 194-AF-2000 and COB 194-AG-2000) to verify implement of the measurement plan.

5.2 Monitoring of Hydrological Parameters

DOE committed to measure two hydrological parameters in the CCA; Culebra groundwater composition and changes in the Culebra groundwater flow direction. These parameters and related parameters are measured and documented in the WIPP environmental monitoring program. These programs are documented in the Groundwater Surveillance Program Plan (WP 02-1, Attachment D.2, COB 194-AK-2000).

The results of this program are documented in the Waste Isolation Pilot Plant Site Environmental Report - Calendar Year 1998 (Selected samples included in this inspection report, COB 194-P-2000). This document describes the groundwater monitoring program and presents results during the year.

The inspection team toured the mobile chemistry laboratory. Mr. Jones and other DOE staff presented a detailed explanation of groundwater composition measurement procedures, such as dissolved minerals, and quality assurance requirements.

5.3 Monitoring of Waste Activity Parameters

DOE committed to measure waste activity in the CCA. This parameter is part of the extensive database collected for each container shipped to WIPP and is stored in the WIPP Waste Information System (WWIS). The WWIS is a software system that screens waste container data and provides reports on the TRU waste sent to WIPP. The requirements for the WWIS are discussed in the WIPP Waste Information Data Management Plan (WP 08-NT.01, Attachment D.3, COB 194-F-2000) and the WIPP Information System Program (WP 08-NT.02, Attachment D.3, COB 194-G-2000).

The facility demonstrated that the WWIS can receive data and that the WWIS can generate reports. The CAO has committed to annual waste activity reports. The inspection team observed how the WWIS records waste activity information provided by the generator sites, and how the computer database produces waste activity reports. The inspection team obtained copies of the Shipment Summary Report, Waste Emplacement Report, Waste Container Data Report, and Biennial Report (Attachment D.3, COB 194-ZB-2000 through COB 194-ZF-2000).

The inspection team reviewed WWIS modification and verification activities. An example of WWIS software modification document is shown in COB 194-Y-2000, which includes the Engineering Change Order, the Software Modification Request Form, and the Revision Information Sheet. This documentation shows that software modifications are documented, verified, and controlled appropriately. Document no. COB 194-Z-2000 contains software validation test activities and is an example of how changes are made to the computer codes and tested to ensure the changes work properly.

5.4 Monitoring of Drilling Related Parameters

DOE committed to measure two drilling related parameters in the CCA: the drilling rate and the probability of encountering a Castile brine reservoir. These parameters are measured as part of the "Delaware Basin Drilling Surveillance Program" (WP 02-PC.02, Attachment D.4, COB 194-AJ-2000). This surveillance program measures or records many parameters related to drilling activities around the WIPP site.

The results of the surveillance program are documented annually in the Delaware Basin Drilling Surveillance Program - Annual Report for October 1998 through September 1999 (Attachment D.4, COB 194-R-2000) and in a quarterly report (Attachment D.4, COB 194-AB-2000).

Inspectors reviewed the drilling surveillance database and asked that the Active Brine Wells be shown on a map (Attachment D.4, COB 194-AH-2000). The inspection reviewed other maps, such as wells drilled during the past year.

5.5 Monitoring of Subsidence Parameters

DOE committed to measure subsidence at the WIPP site. This parameter is documented as part of the of the "WIPP Underground and Surface Surveying Program" (WP09-ES.01, Attachment D.5, COB 194-B-2000). DOE performs the subsidence survey at the site annually during pre-closure operations. The results of this program are reported annually in the WIPP Subsidence Monument Leveling Survey (Attachment D.5, COB 194-E-2000).

The inspection team examined how horizontal and vertical surveys are performed. Inspectors also examined the survey equipment used, the methods used to record and check field data, how these data are input into the computer database and are used to produce the needed reports, Digital Leveling Log Sheets, and the resulting QA checkprints (Attachment D.5, COB 194-W-2000).

6.0 Summary of finding, observation, concerns, and recommendations.

Inspectors concluded that DOE has adequately maintained programs to monitoring the necessary ten parameters during pre-closure operations. DOE/WID reports the results of these monitoring activities as specified in the CCA.

Attachment A: Inspection Checklist

40 CFR 194.42 - DOE WIPP Monitoring Commitments Checklist

	Pre-closure Monitoring Commitments		
#	Question	Comment (Objective Evidence)	Result
	Geomechanical Parameters		
1	Does DOE demonstrate that they have implemented plans/programs/procedures to measure - a) Creep Closure; b) Extent of Deformation; c) Initiation of Brittle Deformation and d) Displacement of Deformation Features during the pre-closure phase of operations as specified in the CCA part of the geomechanical monitoring system? (CCA, Volume 1, Table 7-7; App MON, Table MON-1) 40 CFR 194.42 (c) and (e)	Item #7, below, documents the program planned to measure, document, report, and QA these four activities. Section 3.0, item #7 documents the Geomechanical Monitoring Program and records the activities associated with this program, the methods planned to be used, and the reporting plans. Section 4.0, item #7 documents the quality assurance requirements of these activities. Items #25, #43, and #44 are examples of raw data collection and verification. Item #4 is an example of results of these monitoring activities. The inspection team toured and reviewed the computer system and database systems used to collect and process these data.	Sat.
2	Does DOE demonstrate that they have implemented an effective quality assurance program for item 1 above? 40 CFR 194.22	EPA performed a quality assurance inspection June 30, 1999, and found the program at DOE/WID adequate.	Sat.
3	Does DOE demonstrate that the results of the geotechnical investigations are reported annually? (CCA, App. MON, Page MON-10)	Item #7, page 8 requires that analysis will be performed annually and the results will be published in the geotechnical analysis report.	Sat.

Documents Reviewed:
#7 - WIPP Geotechnical Engineering Program Plan - WP 07-01, Revision 2
#25 - Sample - raw data - GIS Field Data Sheets, Room Closure Measurements
#43 - Sample - raw data - CVPT Field Data Checkprint
#44 - Sample - raw data - EXTN Field Data Checkprint
#4 - Geotechnical Analysis Report for July 1998 - June 1999

40 CFR 194.42 - DOE WIPP Monitoring Commitments Checklist

	Pre-closure Monitoring Commitments		
#	**Question**	**Comment (Objective Evidence)**	**Result**
	Hydrological Parameters		
1	Does DOE demonstrate that they have implemented plans/programs/procedures to measure - a) Culebra Groundwater Composition; b) Change in Culebra Groundwater Flow Direction during the pre-closure phase of operations as specified in the CCA part of WIPP's groundwater monitoring plan? (CCA, Volume 1, Table 7-7; App MON, Table MON-1) 40 CFR 194.42 (c) and (e)	Item #46, below, documents the program planned to measure, document, report, and QA these two activities. Item #46 documents the Groundwater Surveillance Program Plan and records the activities associated with this program, the methods planned to be used, and the reporting plans. Section 4.0, item #46 documents the quality assurance requirements of these activities. Item #22 is an example of results of these monitoring activities. The inspection team toured and evaluated the chemical analysis performed in the mobile laboratory.	Sat.
2	Does DOE demonstrate that they have implemented an effective quality assurance program for item 1 above? (CCA, App MON, Page MON-22) 40 CFR 194.22	EPA performed a quality assurance inspection June 30, 1999, and found the program at DOE/WID adequate.	Sat.
3	Does DOE demonstrate that the results of the groundwater monitoring program are reported annually? (CCA, App. MON, Page MON-22)	Item #46, page 28 documents that results of monitoring will be reported annually and will be published in the Annual Site Environmental Report (ASER).	Sat.

Documents Reviewed:
#46 - Groundwater Surveillance Program Plan - WP 02-1, Revision 3
#22 - Waste Isolation Pilot Plant Site Environmental Report - Calendar Year 1998, selected samples

40 CFR 194.42 - DOE WIPP Monitoring Commitments Checklist

	Pre-closure Monitoring Commitments		
#	Question	Comment (Objective Evidence)	Result
	Waste Activity Parameters		
1	Does DOE demonstrate that they have implemented plans/programs/procedures to measure - a) Waste Activity? (CCA, Volume 1, Table 7-7; App MON, Table MON-1) 40 CFR 194.42 (c) and (e)	WWIS will be used to measure and store waste activity among other things. Item #12, below, documents the program planned to measure, document, report, and QA this activity. Item #12 documents the WWIS Program and records the activities associated with this program, the methods planned to be used, and the reporting plans. Items #33 through #37 are examples of the many reports that can be generated using the WWIS. Items #30 and #31 are example of the QC controls on the modification and testing of the WWIS computer codes. The inspection team toured and reviewed the WWIS computer system and the database computer program. The team reviewed the query capabilities of the system to produce waste activity reports.	Sat.
2	Does DOE demonstrate that they have implemented an effective quality assurance program for item 1? (CCA, App WAP, page C-30) 40 CFR 194.22	EPA performed a quality assurance inspection June 30, 1999, and found the program at DOE/WID adequate.	Sat.
3	Does DOE demonstrate that the results of the waste activity parameters are reported annually? (CCA Volume, Section 7.2.4 Reporting)	Item #12, page 15 documents that results of monitoring will be reported annually.	Sat.

Documents Reviewed:
#12 - WIPP Waste Information System Program - WP 08-NT.02, Revision 0
#33 - Sample - WWIS Shipment Summary Report
#34 - Sample - WWIS Waste Emplacement Report
#35 - Sample - WWIS Repository Report
#36 - Sample - WWIS Waste Container Data Report
#37 - Sample - WWIS Biennial Report
#30 - WWIS Software Modification Documents
#31 - WWIS Software Validation Test Documents

40 CFR 194.42 - DOE WIPP Monitoring Commitments Checklist

	Pre-closure and Post Closure Monitoring Commitments		
#	**Question**	**Comment (Objective Evidence)**	**Result**
	Drilling Related Parameters		
1	Does DOE demonstrate that they have implemented plans/programs/procedures to measure - a) Drilling Rate; and b) Probability of Encountering a Castile Brine Reservoir? (CCA, Volume 1, Table 7-7; App MON, Table MON-1) 40 CFR 194.42 (c) and (e)	Item #10, below, documents the program planned to measure, document, report, and QA these two activities. Item #10 documents the Delaware Basin Drilling Surveillance Plan and records the activities associated with this program, the methods planned to be used, and the reporting plans. Section 6.0, item #10 documents the quality assurance requirements of these activities. Item #42 is an example of the information produced from the surveillance database. Item #42 is a copy of the annual report; page 8 shows the 1999 calculation of the drilling rate and page 10 shows a discussion of Castile brine pockets. The inspection team toured and reviewed the computer and database system used to record and store drill hole data. The team reviewed the report and mapping capabilities of the computer system..	Sat.
2	Does DOE demonstrate that they have implemented an effective quality assurance program for item 1 above? (CCA, App DMP, page DMP-9) 40 CFR 194.22	EPA performed a quality assurance inspection June 30, 1999, and found the program at DOE/WID adequate.	Sat.
3	Does DOE demonstrate that the results of the drilling related parameters are reported annually? (CCA Volume, Section 7.2.4 Reporting; App DMP, page DMP-9)	Item #10, page 5 documents that results of monitoring will be reported annually.	Sat.

Documents Reviewed:
#10 - Delaware Basin Drilling Surveillance Plan - WP 02-PC.02, Revision 0
#45 - Map of Active Brine Injection Wells
#42 - Delaware Basin Drilling Surveillance Program - Annual Report for October 1998 through September 1999

40 CFR 194.42 - DOE WIPP Monitoring Commitments Checklist

	Pre-closure and Post Closure Monitoring Commitments		
#	Question	Comment (Objective Evidence)	Result
	Subsidence Measurements		
1	Does DOE demonstrate that they have implemented plans/programs/procedures to measure - a) Subsidence measurements? (CCA, Volume 1, Table 7-7; App MON, Table MON-1) 40 CFR 194.42 (c) and (e)	Item #5, below, documents the program planned to measure, document, report, and QA these two activities. Item #5 documents the WIPP Underground & Surface Surveying Program and records the activities associated with this program, the methods planned to be used, and the reporting plans. Section 4.0, item #5 documents the quality assurance requirements of these activities. Item #9 is a copy of the annual report for 1999. Item #29 is a sample of raw data collected during the subsidence survey and a QA checkprint. The inspection team toured and reviewed the computer and database system used to record and store subsidence survey data. The team reviewed the report and mapping capabilities of the computer system.	Sat.
2	Does DOE demonstrate that they have implemented an effective quality assurance program for item 1? 40 CFR 194.22	EPA performed a quality assurance inspection June 30, 1999 and found the program at DOE/WID adequate.	Sat.
3	Does DOE demonstrate that the results of the subsidence measurements are reported annually? (CCA Volume, Section 7.2.4 Reporting)	Item #5, page 10 documents that results of monitoring will be reported annually.	Sat.

Documents Reviewed:
#5 - WIPP Underground and Surface Surveying Program - WP 09-ES.01, Revision 1
#29 - Sample - raw survey data - Digitial Leveling Log Sheet and Checkprint
#9 - WIPP Subsidence Monument Leveling survey - 1998

Attachment B:
Opening and Closing Meeting Attendance Sheets

EPA 40 CFR 191A/194.42 Inspection
June 20 – 22, 2000
Opening Meeting

Date 6/20/00

PRINTED NAME	SIGNATURE	ORGANIZATION	PHONE NUMBER
KEVIN DONOVAN	[signature]	W ES&H	(505) 234 -8325
DAVE SPEED	[signature]	W NTP	505.234.7490
Mark Polley	[signature]	W ops	234-8928
Marsha Beekman	Marsha L. Beek	W ES&H	505 234-8495
STEVE CASEY	[signature]	W ES&H	234-8414
BOB CULLUM	[signature]	W ENG	234-8683
Wes Root	Wes Root	W ES&H	234-8253
Stewart Jones	Stewart Jones	W ES&H	234-8293
S. J. PATCHET	[signature]	W GEOTECH ENG	234-8370
A.E. STRAIT	AE Strait	W ENG	234-8634
W.T. Bartlett	WTBartlett	EEG	505-828-1003
B. Lilly	Bruce Lilly	CAO/DOE	8136
R. Farrell	Richard Farrell	CAO/DOE	8318

CCB 191A-~~N~~-2000(9)

EPA 40 CFR 191A/194.42 Inspection
June 20 – 22, 2000
Opening Meeting

Date 6/20-22/00

PRINTED NAME	SIGNATURE	ORGANIZATION	PHONE NUMBER
J. EPSTEIN	J. Epstein	WESTINGHOUSE	505-234-8200
JOE P. HARVILL	Joe P. Harvill	CTAC	505-234-3128
FAROK SHARIF	Farok Sharif	Westinghouse	505-234-7376
SUBHASH SETHI	[illegible]	Westinghouse	505-234-8182
Dave Kump	D. R. Kump	Westinghouse	505-234-8486
Don Harward	J. Harward	Westinghouse	(505)234-8285
Chuck Byrum	Charles O. Byrum	U.S. EPA	(214) 665-7555
Nick Stone	Nick Stone	US EPA	214 665 7226
CHUAN-FU WU	Chuan-Fu Wu	DOE/CAO	(505) 234-7552
George T. Basabilvazo	George T. Basabilvazo	DOE/CAO	(505) 234-7488
L. J. DALTON	L. J. Dalton	Westinghouse	(505) 234-748

Bill Bartlett EEG
Jim Kenny EEG

CB 191A - N - 2000(6)

EPA Inspection
6-20-00 Daily Debriefing Meeting

Richard Farrell	R Farrell	CAO/DOE	505.234.8[illegible]
A.E. STRAIT	AE Strait	(W)/ENG	505-234-86[illegible]
SUBHASH SETHI	[illegible]	(W)/OPS.	505-234-81[illegible]
JOE EPSTEIN	[illegible]	W GM	505-234-7[illegible]
Nick Stone	Nick Stone	EPA	214 665-722[illegible]
Chuck Byrum	Charles O. By[illegible]	EPA	214665-7555
Dave Kump	D R Kump	W	505-234-84[illegible]
Wes Root	Wes Root	W	505-234-8253
Mark Polley	[illegible]	W	505-234-8928

COB 191A-N-2000(c)

Opening Meeting - 2nd Day
EPA Inspection (Cont.)
6/21/00

Name	Signature	Organization	Phone #
Dave Kump	D.R. Kump	W	505-234-84.
Chuck Byrum	Charles O Byr	EPA	214 665 755
Nick Stone	Nick Stone	EPA	214 665 7226
Richard Farrell	Richard Farrell	~~EPA~~ CAO/DOE	505. 234. 8318
Marsha L. Beekman	Marsha L. Beek	W ES&H	505 234-8495
Stewart B. Jones	Stewart B Jones	W ES&H	505 234-8293
Mark Polley	M Polley	W OPS	505 234-8928
Jim Kenney	Jim W. Kenney	EEG	505 885-9675

CBFO MIA - ~~NE~~ CB 2000 (d)

EPA 40 CFR 191A/194.42 Inspection
June 20 – 22, 2000
Close-out Meeting

Date 6/22/00

PRINTED NAME	SIGNATURE	ORGANIZATION	PHONE NUMBER
Don Harward	J. Harward	R/S & EM	X8285
D. R. Kump	D. R. Kump	ES&H/Nuclear Compliance	234-8486
SUBHASH SETHI	[signature]	W/Operations	234-8182
GARY YOUNG	G Young	PM	234-7638
KEVIN DONOVAN	Kevin Donovan	W ES&H	234-8325
A.E. STRAIT	AE Strait	W ENG	234-8636
MARSHA L. BEEKMAN	M.L. Beekman	W ES&H	234-8495
Nick Stone	Nick Stone	EPA	214 665 7226
Chuck Byrum	Chuck Byrum	EPA	214 665 7555
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CEB 191A-N-2000(e)

EPA 40 CFR 191A/194.42 Inspection
June 20 – 22, 2000
Close-out Meeting

Date 6/22/00

PRINTED NAME	SIGNATURE	ORGANIZATION	PHONE NUMBER
S. J. PATCHET	[signature]	W Gentech Eng	505-234-8370
Jim Kenney	Jim Kenney	EEG	505-885-9675
JOE P. HARVILL	[signature]	CTAC	505-234-3128
Cynthia Zvonar	Cynthia Zvonar	DOE/CAO	" " 7495
Bob Cullen	[signature]	W/ENGR	8683
JOE EPSTEIN	[signature]	W GM	505234-7400

CEB 191A-N-2000(e)

Attachment C: Documents Reviewed

#	Documents Reviewed and Copies Received Document Title	Subject Matter	Source and Location	Copy
1	Table 7-7 from Chapter 7 of the CCA; Pre-closure and Post-closure Monitored Parameters.	Parameters committed by DOE to be measured. COB 194-1-2000	DOE, CCA, Chapter 7, Table 7-7. Attachment D.6	Yes
2	CCA, Appendix MON and Attachment MONPAR. In particular Table MON-1, pages MON-10, MON-29	Both documents discuss the pre- and post-closure parameter selected to be monitored at the WIPP site. COB 194-2-2000	DOE, CCA documentation. *Not included in this report	No*
3	Opening Meeting Presentation Materials	WWIS developments by Dave Speed COB 194-#-2000	DOE/WID Attachment D.6	Yes
4	Geotechnical Analysis Report for July 1997 - June 1998	This report is an example of the results of the geomechanical monitoring program. COB 194-A-2000	DOE/WID Attachment D.1	Yes
5	Subsidence Monitoring: WIPP Underground and Surface Surveying Program WP 09-ES.01 Revision 2	Demonstrates DOE's implementation of subsidence monitoring. COB 194-B-2000	DOE/WID Attachment D.5	Yes
6	Hydrological Monitoring: WIPP Groundwater Monitoring Program Plan WP 02-1 Revision 5	Demonstrates DOE's implementation of hydrological monitoring. COB 194-C-2000	DOE/WID	No*

	Documents Reviewed and Copies Received	[illegible]		
#	**Document Title**	**Subject Matter**	**Source and Location**	**Copy**
7	Geomechanical Monitoring: WIPP Geotechnical Engineering Program Plan WP 07-01, Revision 2	Demonstrates DOE's implementation of geomechanical monitoring. COB 194-AI-2000	DOE/WID Attachment D.1	Yes
8	Intentionally left blank because of duplicate.			
9	WIPP Subsidence Monument Leveling Survey - 1999 DOE/WIPP 00-2293	This report is an example of the results of the geomechanical monitoring program. COB 194-E-2000	DOE/WID Attachment D.5	Yes
10	Delaware Basin Drilling Surveillance Plan WP 02-PC.02, Revision 0	Documents DOE's drilling monitoring plan. COB 194-AJ-2000	DOE/WID Attachment D.4	Yes
11	WIPP Waste Information System Data Management Plan WP 08-NT.01, Revision 0	Demonstrates DOE's implementation of waste activity monitoring. COB 194-G-2000	DOE/WID Attachment D.3	Yes
12	WIPP Waste Information System Program WP 08-NT.02, Revision 0	Demonstrates DOE's implementation of waste activity monitoring. COB 194-F-2000	DOE/WID Attachment D.3	Yes

Documents Reviewed and Copies Received				
#	Document Title	Subject Matter	Source and Location	Copy
13	Waste Stream Profile Form Review and Approval Program WP 08-NT.03 Revision 0	Demonstrates DOE's implementation of waste activity monitoring. COB 194-H-2000	DOE/WID *Not included in this report.	No*
14	WIPP Waste Information System Software Quality Assurance Program WP 08-NT.04, Revision 0	Demonstrates DOE's implementation of waste activity monitoring. COB 194-I-2000	DOE/WID	No*
15	WIPP Waste Information System Software Verification and Validation Plan WP 08-NT.05, Revision 0	Demonstrates DOE's implementation of waste activity monitoring. COB 194-J-2000	DOE/WID	No*
16	WIPP Waste Information Software Requirements Specification WP 08-NT.06, Revision 0	Demonstrates DOE's implementation of waste activity monitoring. COB 194-K-2000	DOE/WID	No*
17	WIPP Waste Information System Software Design Description WP -08-NT.07, Revision 0	Demonstrates DOE's implementation of waste activity monitoring. COB 194-L-2000	DOE/WID	No*
18	WIPP Waste Information System Configuration Management Plan WP 08-NT.08, Revision 0	Demonstrates DOE's implementation of waste activity monitoring. COB 194-M-2000	DOE/WID	No*

#	Documents Reviewed and Copies Received Document Title	[illegible] DOE Documents Subject Matter	Source and Location	Copy
19	WID Quality Assurance Program Description WP 13-1 Revision 18	Demonstrates DOE's implementation of quality assurance program. COB 194-N-2000	DOE/WID *Not included in this reprot.	No*
20	Delaware Basin Drilling Surveillance Program - Annual Report for October 1998 Through September 1999 DOE/WIPP99-2308 Revision 0	Demonstrates DOE's implementation of drilling surveillance program. COB 194-R-2000	DOE/WID	No*
	Intentionally left blank because of duplicate.			No*
22	Waste Isolation Pilot Plant Site Environmental Report for 1998, October 1999 DOW/WIPP 99-2225	Example of the results of the environmental monitoring program, in particular hydrological parameters. COB 194-P-2000	DOE/WID ^Selected Samples. Attachment D.2	Yes^
23	Geotechnical Department Approval of Waste Emplacement in Panel 1 Room 1. June 21, 2000	COB 194-Q-2000	DOE/WID	No*
24	Summary of Underground Geotechnical Observations For the Period of March 2000 to April 2000. - HA:00:02039	COB 194-U-2000	DOE/WID	No*

	Documents Reviewed and Copies Received			
#	Document Title	Subject Matter	Source and Location	Copy
25	Sample - raw data - GIS Field Data Sheets, Room Closure Measurements	COB 194-T-2000	DOE/WID Attachment D.1	Yes
26	Ground Control Monitoring System Data Logger SBC.C Software Implementation Section	This document addresses the Software Life Cycle - plan stipulates a commented source code listing of SBC.C and a line by line verification of the code. COB 194-S-2000	DOE/WID *Not included in this report	No*
27	Ground Control Monitoring System Data Logger Software Quality Assurance Plan	Plan provides requirements for the development, modification, use, configuration management and retirement of the Ground Control Monitoring System data logger software. COB 194-X-2000	DOE/WID	No*
28	Ground Control Monitoring System Data Logger Software Requirements Section	This document addresses the SBC Software Life Cycle Requirements Section as outlined in Item #27 above. COB 194-R-2000	DOE/WID	No*
29	Sample - raw survey data - Digital Leveling Log Sheet (Loop)	COB 194-W-2000	DOE/WID Attachment D.5	Yes
30	WWIS Software Modification Documents	COB 194-Y-2000	DOE/WID Attachment D.3	
31	WIPP Waste Information System - Version 4.3, Software Validation Test SP-WO-00430	Documents the testing of modifications to the WWIS computer code(s). Verifies that changes to the code(s) are working correctly. COB 194-Z-2000	DOE/WID Attachment D.3	Yes

#	Documents Reviewed and Copies Received Document Title	194.42 Monitoring Inspection – June 2000 – DOE Documents Subject Matter	Source and Location	Copy
32	WWIS Software Testing Exception Sheet	Documents errors with the WWIS system and records corrections and changes. COB 194-ZA-2000	DOE/WID *Not included in this report.	No*
33	Sample - WWIS Shipment Summary Report RP0390	Sample report from the WWIS listing the total activity on a drum by drum basis. COB 194-ZB-2000	DOE/WID Attachment D.3	Yes
34	Sample - WWIS Waste Emplacement Report RP0440	List the container number, site id, emplacement date, matrix code, etc for each drum COB 194-ZC-2000	DOE/WID Attachment D.3	Yes
35	Sample - WWIS Repository Report RP0530	List the number of drums and standard waste boxes in the underground. COB 194-ZD-2000	DOE/WID Attachment D.3	Yes
36	Sample - WWIS Waste Container Data Report RP0360	List specific details of contents and activity of each container. COB 194-ZE-2000	DOE/WID Attachment D.3	Yes
37	Sample- WWIS Biennial Report RP0450	List total weight in Kg of waste emplaced. COB 194-ZF-2000	DOE/WID Attachment D.3	Yes
38	2000 Environmental Monitoring Sampling Schedule	List all monitoring and sampling activities during the year 2000. COB 194-AA-2000	DOE/WID Attachment D.6	Yes

	Documents Reviewed and Copies Received			
#	**Document Title**	**Subject Matter**	**Source and Location**	**Copy**
39	Delaware Basin Monitoring Program Quarterly Report - June 2000	Documents the Delaware Basin surveillance program during fiscal year 2000 third quarter. COB 194-AB-2000	DOE/WID Attachment D.4	Yes
40	Delaware Basin Monitoring Program Quarterly Report - March 2000	Documents the Delaware Basin surveillance program during fiscal year 2000 second quarter. COB 194-AC-2000	DOE/WID *Not included in this report	No*
41	Delaware Basin Monitoring Program Quarterly Report - December	Documents the Delaware Basin surveillance program during fiscal year 2000 first quarter. COB 194-AD-2000	DOE/WID *Not included in this report	No*
42	Delaware Basin Monitoring Annual Report - September 1999 DOE/WIPP-99-2308	Documents the monitoring of Delaware Basin drilling activities for the year. COB 194-AE-2000	DOE/WID Attachment D.4	Yes
43	Sample - raw data - CVPT Field Data Checkprint.	Used as a QA check to verify that the data input into the database is corrected. COB 194-AF-2000	DOE/WID Attachment D.1	Yes
44	Sample - raw data - EXTN Field Data Checkprint	Used as a QA check to verify that the data input into the database is corrected. COB 194-AG-2000	DOE/WID Attachment D.1	Yes
45	Map of Active brine injection wells in the Delaware Basin	COB 194-AH-2000	DOE/WID Attachment D.4	Yes
46	WIPP Groundwater Surveillance Program Plan WP 02-1, Revision 3	Demonstrates DOE's implementation of hydrological monitoring. COB 194-AK-2000	DOE/WID Attachment D.2	Yes

Attachment D.1:

Geomechanical Documents Reviewed

Effective Date: 03/16

WP 07-01

Revision 2

WIPP Geotechnical Engineering Program Plan

Cognizant Section: Geotechnical Engineering

Approved By: S. J. Patchet

Cognizant Department: Engineering

Approved By: J. J. Garcia

COB 194-AI-2000
Same as 1999
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TABLE OF CONTENTS

1.0 INTRODUCTION

This document defines the field programs and investigations to be carried out by the Waste Isolation Division (WID) Geotechnical Engineering Section. The geotechnical engineering programs are designed to provide scientific information necessary to establish a high level of understanding of site characteristics and to assess the stability and performance of the underground facility. Programs currently consist of the following activities:

- Geosciences
- Geomechanical Monitoring
- Rock Mechanics
- Ground Control

These programs will be implemented and controlled by this program plan.

1.1 Background

The programs listed in Section 2 will demonstrate the safe disposal of transuranic waste, both in the short-term (during the operational life of the facility) and in the long-term (following decommissioning), that will satisfy the appropriate federal regulations governing isolation of the waste. The data will increase confidence in the effectiveness and safety of the underground operations, validate the design, support site characterization and performance assessment activities, and support activities required for research and technological development.

Drivers for these programs include the Consultation and Cooperation Agreement with the state of New Mexico, which stipulates continuing studies of the site geology; the Environmental Protection Agency's standards for management of transuranic waste; the Resource Conservation and Recovery Act; and the Mine Safety and Health Administration. These programs implement the applicable portions of systems AUØØ and EMØØ System Design Description (SDD). The programs will also ensure that the facility operates safely and that data are available to make decisions for managing and performing engineering and operational activities.

Field activities will be organized into four programs that cover:

- Geosciences
- Data collection from geomechanical instrumentation
- Rock mechanics evaluation
- Ground control assessments

Each field program will be controlled by a program plan describing the general scope of the investigation, its methods, and quality assurance requirements.

1.2 Geosciences Program

The Geosciences Program will continue confirmation of site suitability based on field activities such as geologic mapping of the facility horizon excavations and logging of cores. These activities will be used to characterize, demonstrate the continuity of, and document the geology exposed in the underground excavations. The program also will maintain a storage facility for site-generated geologic samples and a local seismic monitoring system.

1.3 Geomechanical Monitoring Program

The Geomechanical Monitoring Program will provide data on the Waste Isolation Pilot Plant (WIPP) geotechnical performance design for design validation and the short-term and long-term behavior of underground openings, and routine evaluations of the safety and stability of excavations. Data on the stability and closure of underground excavations will be used to identify areas of potential instability and allow remedial actions to be taken.

Monitoring of geotechnical parameters will be performed using geomechanical instruments, including tape extensometer stations, convergence meters, borehole extensometers, piezometers, strain gauges, load cells, crack meters, and other instruments installed in the shafts and drifts of the WIPP facility.

1.4 Rock Mechanics Program

The Rock Mechanics Program will assess of the performance of the underground facility. Data from geomechanical monitoring and geosciences observations will be used to evaluate the current and future performance of the excavations. Numerical modeling and empirical methods will be used to evaluate the effects of proposed design changes and the long-term behavior of the underground facility.

1.5 Ground Control Program

The Ground Control Program will ensure that the underground is safe from any unexpected roof or rib falls. It will provide the experience necessary to design ground control systems for the host rock, to monitor ground control system performance through data and observations, and to allow projections to be made regarding future ground support requirements.

2.0 ADMINISTRATION

2.1 Organization

The WID organizational structure is described in the WID Quality Assurance Program Description (WP 13-1). Geotechnical Engineering reports to the Engineering Department senior manager.

2.2 Responsibilities

The Geotechnical Engineering manager and staff are responsible for achieving and maintaining quality in the geotechnical engineering programs.

2.3 Training and Qualifications

Personnel who perform specific tasks associated with geological and geotechnical data collection, engineering assessments, and quality assurance/quality control measures will be trained and qualified in the application of the specific requirements to complete their tasks. The minimum training requirements for engineering personnel are identified in the Engineering Technical Training Requirements Policy.

3.0 TECHNICAL PROGRAM DESCRIPTION

3.1 Geosciences Program

The Geosciences Program contains activities that continue confirmation of site suitability through surface and underground field investigations. These activities will generate data used in monitoring the repository and in rock mechanics studies. Information from the Geosciences Program will be used to document the existing geologic conditions and characteristics and to monitor for changes resulting from the excavations. Activities associated with this program will include geologic and fracture mapping, maintenance of a facility for the storage of geologic samples (the Core Library), seismic monitoring and evaluation, and other activities performed as needed. The program will describe the general scope of investigations, the methods, and program requirements. The plan will be updated periodically to reflect additions and changes to the program.

3.1.1 Background

The Los Medanos area has been studied since 1974 to assess site capability for isolation of radioactive waste. The present WIPP site was selected in 1976 and has been under continuous investigation since that time as a site for containment and isolation of transuranic radioactive waste. Because geology is the principal factor in the isolation of the waste from the accessible environment, the Geosciences Program provided important data for site characterization and was integral to the decision on the design of the facility. Extensive geologic characterization of drifts and shafts was performed under the Site and Preliminary Design Validation Program for confirmation of site suitability. The program provided the basis for the decision to proceed with construction of the WIPP facility.

The Geotechnical Engineering Geosciences Program was developed to continue confirmation of site suitability based on field activities such as geologic mapping of the facility and near surface stratigraphic horizons, core logging, and geophysical surveys. These activities characterize, demonstrate the continuity of, and document the geology at the site. The program maintains a library of site-generated geologic samples and quarterly reporting of the results of local seismic monitoring. The program is also responsible for the collection of geologic and structural data and other section activities as required.

3.1.2 Purpose

The purpose of the Geosciences Program is to confirm the suitability of the site based on continuing field activities.

3.1.3 Scope

Site investigations will be performed as required, or as determined useful, for enhancement of the site geologic characterization knowledge base. Activities will include reconnaissance geologic mapping of new excavations, detailed geologic mapping, investigations of regional exposures, and geologic support to projects conducted by other site participants. The activities associated with the Geosciences Program are designed to:

- Provide additional site geological characterization based on geologic mapping of excavations and core logging

- Maintain a current data base on mineralogy, chemistry, and textural feature characteristics of the local geology

- Maintain a current level of knowledge on the geohydrology of the Salado and Rustler Formations based on geologic, hydrologic, and geochemical data

- Monitor the local seismicity using a series of surface-based seismographs. As part of this activity, analyses will be performed to determine if any correlation of seismic events with mining or petroleum recovery operations can be established

3.1.4 Methods

Routine tasks will be carried out according to approved WIPP procedures. Activities in development or those not expected to be performed routinely will be performed in accordance with industry standards or individual program plans that supplement this program plan.

Routine Activities

- Seismic Monitoring - Seismic monitoring and evaluation will be carried out by the New Mexico Institute of Mining and Technology, a subcontractor to WID.

- Geologic Mapping - Geologic mapping will be performed in newly excavated areas and when the cognizant engineer or Geotechnical Engineering manager deems it necessary. The mapping results will be documented in the annual geotechnical analysis reports and appropriate topical reports.

  All drifts and rooms in which geologic mapping was not conducted will be visually inspected by the cognizant engineer, or designee, within three months of excavation to verify that the exposed rock units are laterally continuous and similar to those exposed in the mapped areas of the facility. Any unusual features will be reported in the annual geotechnical analysis reports.

- Fracture Mapping - Fracture mapping will be performed and carried out by the cognizant engineer, designee, or Geotechnical Engineering manager at locations selected in accordance with accepted industry practice. Observations from boreholes and excavated surfaces will be used in performance assessments of the underground facility.

- Core Library Operations - Geotechnical Engineering will maintain a repository for geologic samples that have been determined necessary for long-term storage. Approved WIPP procedures define the proper methods for maintaining the sample repository, the submittal of core to the Core Library, maintenance of the Core Storage Facility (inventory, handling, and distribution), authorization for access to view the core on-site, and authorization to remove samples from the library.

Other Activities of the Geosciences Program

Test plans will be developed for geoscience activities that are in a developmental stage or are not routinely performed. They will include or reference the appropriate procedures to ensure that all necessary steps for completion are carried out. The plans will detail specific plans that describe the activity, location, procedure, etc.

3.2 Geomechanical Monitoring Program

The Geomechanical Monitoring Program will monitor the geomechanical response of the underground openings after mining. It will also monitor geotechnical instruments installed in the shafts and drifts of the WIPP facility. Geotechnical instrumentation installed in the shafts and underground includes tape extensometer points, convergence meters, borehole extensometers, piezometers, strain gages, load cells, and crack meters. The instrumentation is sensitive enough to detect small changes in rock displacements and rock stresses.

Information generated by this program will be documented in annual geotechnical analysis reports. The data will be documented more frequently as recommended by the cognizant engineer or manager. An assessment of convergence measurements and geotechnical observations will be made after each round of measurements. The results of this assessment will be distributed to affected underground operations, engineering, and safety managers.

This plan describes the general scope of the investigation, methods, and program requirements, and will be updated periodically to reflect additions and changes.

3.2.1 Background

The instrumentation system has provided data on the performance of the WIPP design for design validation and for projecting the long-term behavior of the underground openings, and routine evaluation of safety and excavation stability. From an operational standpoint, the geomechanical data allow the identification of areas of potential instability and for remedial action to be taken. To determine the long-term behavior of the repository, assessments will rely heavily on the extrapolation of in-situ data, taken over a period of years, to predict thousands of years of repository performance.

The engineering performance of the WIPP host rock is important in the assessment of the design of the operating facility and its long-term performance. Of significance are the time-dependent properties of the salt. Sandia National Laboratories has carried out extensive experimental work to establish an appropriate, constitutive relationship for salt that can predict its in-situ mechanical performance. To validate the adequacy of the facility design, field data from geomechanical instrumentation are used to determine actual mechanical performance of the shafts and excavations at the facility horizon.

3.2.2 Purpose

The purpose of the Geomechanical Monitoring Program is to determine the geomechanical performance of the underground excavations at WIPP. Data on stability and closure are needed for operational considerations and for performance assessment.

3.2.3 Scope

The activities associated with the Geotechnical Monitoring Program are designed to:

- Maintain and augment the geotechnical instrumentation system in the WIPP underground and upgrade the automatic data acquisition system as necessary
- Monitor geotechnical instrumentation on a regular basis and maintain a current data base of instrument readings
- Evaluate the geotechnical instrumentation data and prepare regular reports that document the data and analyses describing the stability and performance of underground openings
- Recommend corrective or preventive measures to ensure excavation stability and safe operation of the facility

3.2.4 Methods

The process by which geomechanical monitoring of an area is initiated may vary as part of operational excavation monitoring or research testing. Proper documentation and analysis is common to all. Installation and monitoring of the instruments will be governed by approved WIPP procedures. The instrumentation will be monitored remotely using data loggers or read manually. Routine tasks will be carried out according to approved WIPP procedures. Activities which are in development, or which are not expected to be performed routinely, will be performed in accordance with industry standards or individual program plans that supplement this program plan.

Data Acquisition

The remotely polled instruments are connected to a surface computer through a system of cables, termination boxes, and data loggers. The manually read instruments will be monitored using electronic read-out boxes and mechanical measuring devices. The data will be collected on a quarterly basis at a minimum, but more frequent readings may be collected as determined by the cognizant engineer or manager.

Geomechanical Data Logging System

The system consists of surface computers, modems, data loggers, and associated interconnecting cabling. The instrumentation is routed to local termination cabinets or accessor boxes at various locations in the underground. These contain the electronic hardware needed for multiplexing, signal conditioning, data conversion, and communicating with the surface computers, which are connected by a dedicated communications data link cable. The surface computers communicate through modems using a series of communication and data management software programs. The data from the instruments will be maintained in individual data bases for each instrument type.

Instrumentation

The instrumentation used at WIPP is widely accepted in the geotechnical and mining industry. Geomechanical instrumentation installed in the shafts and underground includes tape extensometer points, convergence meters, borehole extensometers, rockbolt load cells, pressure cells, crack meters, strain gauges, and piezometers. The instrumentation is sensitive to small changes in rock displacement and stress. The geomechanical instruments will be installed and monitored in accordance with approved procedures or written instructions. Instrument types, monitoring usage, and typical installation locations are listed in the following table.

GEOMECHANICAL MONITORING INSTRUMENTATION		
INSTRUMENT TYPE	MONITORING USAGE	TYPICAL LOCATION
Tape Extensometer	Manual monitoring of roof-to-floor closure and rib-to-rib closure	Shaft stations, access drifts and disposal panels
Convergence Meter	Manual or remote monitoring of roof-to-floor closure and rib-to-rib closure	Areas of restricted access or with limited vehicular traffic
Multiple Point Borehole Extensometers	Fracture separation in the rock strata and deformation of the rock mass into the excavation	Shafts, shaft stations access drifts and disposal panels
Rockbolt Load Cells	Tensile loads in rockbolts	Selected roof support systems
Earth Pressure Cells	Pressure of the rock creep on the concrete shaft key and on selected roof support systems	Salt Handling Shaft, Waste Shaft, Exhaust Shaft and selected roof support components
Crack Meters	Displacement of a fracture or separation in the rock or between two anchorage points	Shaft brows and selected cable roof support components
Strain Gauges	Deformation of engineered materials (the shaft concrete liner and key and installed rock bolts) due to rock creep	Salt Handling Shaft, Waste Shaft, Exhaust Shaft, and selected roof support components
Piezometers	Groundwater (hydrostatic) pressure behind the shaft liners and keys	Salt Handling Shaft, Waste Shaft and Exhaust Shaft

Data Analysis and Dissemination of Data

The frequency of analyses of geomechanical data will be based on the requirements established in design documents and regulatory requirements, and as determined by the geomechanical instrumentation cognizant engineer. A comprehensive analysis of the data will be performed annually. Results of the analyses will be published in geotechnical analysis reports. Data may be released to external sources more frequently with consent from the Department of Energy.

Assessments of the convergence measurements and other geotechnical observations will be performed after each round of complete measurements. Results will be distributed to affected underground operations, engineering, and safety groups. Data analyses may be performed on a more frequent basis, as recommended by the cognizant engineer or manager.

Calibration

Measurement and data collection equipment used to read the geotechnical instruments will be calibrated in accordance with approved WIPP procedures. Frequency of calibration will be based on manufacturer recommendations upon receipt of the measuring device at the WIPP site, or as determined by the cognizant engineer. Calibration records will be kept on file in Geotechnical Engineering.

Routine Activities

Maintenance will be performed as needed. When an instrument is damaged or erroneous readings are suspected, the instrument will be physically inspected and evaluated for repairs or replacement. If repair efforts are unsuccessful, that instrument will be documented as malfunctioning and monitoring discontinued until the instrument has been replaced or abandoned.

Inspections of the instrumentation and data logging components will be performed during monitoring activities. These inspections check the physical condition of the instrumentation, junction boxes, and cabling for damage, corrosion, and loose parts. Any unusual observations or deterioration will be documented on the Geotechnical Instrumentation System field data sheets and the cognizant engineer will be notified of existing conditions.

The inspection results and performance of the instrumentation and data logging components will be evaluated by comparing the monitoring results against previous readings. These evaluations will be used to determine whether the geomechanical instrumentation and data acquisition system are performing as anticipated.

Other Activities of the Geomechanical Monitoring Program

Test plans will be developed for geomechanical monitoring activities that are either in a developmental stage or not routinely performed. These plans will include or reference the appropriate procedures to ensure that all necessary steps to complete the activity are carried out and will detail specific plans that describe instrument characteristics, locations, procedures, etc. These activities may include the installation and monitoring of new instrument types to evaluate their adequacy for use in salt. Changes to the remote monitoring equipment and software routines will be documented in accordance with approved WIPP procedures.

3.3 Rock Mechanics Program

This program assesses the current and future performance of the underground facility. Its statistical and empirical data methods and numerical modeling codes, modified for use in salt rock, provide the process for analyzing data collected from geotechnical instruments and visual observations. The results follow approved WIPP procedures and will be published in annual geotechnical analysis reports, or more frequently as recommended by the cognizant engineer or manager.

This program plan describes the general scope, methods, and program requirements of investigations and will be updated periodically to reflect additions and changes.

3.3.1 Background

The Rock Mechanics Program assesses of the performance of the WIPP design for design validation and for projecting the long-term behavior of the underground openings and routine evaluation of safety and excavation stability. From an operational standpoint, these assessments will allow the identification of areas of potential instability and the application of remedial actions, if necessary. To validate the adequacy of the facility design, field data from geomechanical instrumentation will be used to determine actual mechanical performance of the shafts and excavations at the facility horizon.

Analytical methods, such as numerical modeling, will be used to determine the potential effects of mining new excavations, excavation sequence, and long-term behavior of the repository. The engineering performance of the WIPP host rock is important to assess the design of the operating facility and its long-term performance. Of significance are the time-dependent properties of the salt. Extensive experimental work and observations have been used to establish an appropriate, constitutive relationship for salt that is used to predict its in-situ mechanical performance. These assessments will rely heavily on the extrapolation of in-situ instrumentation data and field observations.

3.3.2 Purpose

The Rock Mechanics Program provides the capability to assess the geomechanical response of the surface and underground facility due to mining of the underground.

3.3.3 Scope

The activities associated with the Rock Mechanics Program are designed to:

- Assess the geotechnical performance of the underground excavations
- Assess the effectiveness of support systems installed to control areas of potentially unstable ground
- Assess the appropriateness of the current mine design and periodically evaluate the criteria
- Provide geotechnical recommendations for the development of mine design criteria based on analytical assessment of the performance of the existing excavations and from modeling of proposed design changes
- Project excavation performance based on new mining, ground control activities, and facility aging
- Predict the performance of underground excavations based on instrumentation data and supplemented by analytical studies
- Maintain a library of numerical modeling codes that include the state-of-the-art understanding of salt rock mechanics
- Provide recommendations or corrective/preventive measures to underground operations personnel based on the performance and expected usage of the underground facility

3.3.4 Methods

The processes by which rock mechanics activities are completed may vary. Evaluation of the geomechanical performance of the underground openings will use numerical analysis techniques commonly used in the mining and civil engineering industries. The use of these techniques will be governed by WIPP approved procedures for engineering calculations and computer software control.

<u>Routine Activities</u>

The following are routine activities of the Rock Mechanics Program:

- Geomechanical Data Assessment - Assessments of the instrument data and geologic observations will be performed periodically and reported in the annual geotechnical analysis reports and other more frequent topical reports. Complete data analyses will be performed at least once a year. The frequency of data analyses will be based on the geotechnical performance of the excavations and their operational use. The geotechnical data will be evaluated to determine whether conditions exist which warrant closer or, possibly, immediate attention from a ground control standpoint. Geotechnical assessments measure the stability of the openings with respect to operational safety and long-term performance.

- Support System Performance Evaluation - New support system technologies will be evaluated as they become available and will be used as they are proven. Several test sections of support systems have been installed and are being monitored. These systems are instrumented to monitor the performance of the system components. This instrumentation, in conjunction with nearby geomechanical instrumentation, allows assessments of the effectiveness of the support system to be performed.

- Numerical Modeling - Material modeling codes estimate of the performance of the salt rock material based on the material properties and loading conditions provided to the model. These models can be used to determine the potential effects of mining new excavations on the facility or the long-term effect of an excavation on nearby openings. The accuracy of the models can be improved by modifying the code to more accurately represent the actual physical conditions. These modifications may include mesh refinement and the use of input data that more accurately describe the physical properties of the host rock.

Other Activities of the Rock Mechanics Program

Test plans will be developed for rock mechanics activities that are in a developmental stage or are not routinely performed. These plans will include or reference the appropriate procedures to ensure that all necessary steps to complete the activity are carried out and will detail specific plans that describe the activity, location, procedure, etc.

These activities may include investigations of the geomechanical effect of new mining and mine design changes on the performance of the underground facility and subsidence effects. These investigations may require numerical modeling, materials laboratory testing, and field observations. The results will be used to incorporate the latest understanding of the host rock properties into the modeling codes and analytical techniques.

3.4 Ground Control Program

The Ground Control Program provides comprehensive evaluation of the ground conditions and effectiveness of installed support systems throughout the facility. The evaluations will be based on visual observations, analyses of geomechanical instrumentation data, fracture data acquired from observation boreholes, and rockbolt failure data. The design of new support systems will be based on the results of these evaluations.

Ground control issues have been addressed since excavation began at WIPP. Initially only minor spalls were observed. However, as the excavations aged and issues associated with the roof beam began to develop, most of the facility was pattern-bolted with mechanical anchor rockbolts. Because these bolts provide a basically rigid support system, they have a finite life and supplemental systems are required in areas scheduled for decades of use. The support systems must maintain many areas of the underground accessible for the projected life of the facility.

The information generated by this program will be documented in annual assessment reports. Assessment of the performance of the installed ground support systems are performed as recommended by the cognizant engineer or manager. The results of these assessments will be distributed to affected underground operations, engineering, and safety manager sections.

This program plan describes the general scope of the ground control activities, methods, and program requirements, and will be updated periodically to reflect additions and changes to the program.

3.4.1 Background

The operating life of sections of the underground facility may extend to approximately fifty years from the date of excavation. Over time, the strains associated with stress conditions around the excavation result in degradation of the surrounding rock. Safety concerns associated with deterioration of the roof necessitate monitoring, maintenance, and ground control mechanisms to ensure safe working conditions. Roof support systems are currently in place throughout the facility; however, because of creep closure, they may undergo severe stress, have a limited service life, and require periodic replacement.

Many options are currently available for ground control in the mining industry. Technologies used in potash and salt mines are the most applicable to WIPP because of the similar behavior of the rock. A comprehensive testing and evaluation program has been used to determine which ground support components and/or systems are most applicable to specific project requirements. This program consists of many aspects that include continuous visual inspections of the underground opening, extensive geomechanical monitoring, numerical modeling, analysis of rockbolt failures, implementation of ground control procedures, and comprehensive in-situ and laboratory testing, and evaluation of ground support components and systems.

The excavations vary in geometry, geology, age, and operational use. These differences affect the selection of ground control measures, but the ability of the salt to creep or flow with time has the greatest impact on selection of support systems. Salt creep exerts strong forces, both vertical and horizontal, on any control mechanism. During the time that the underground has been active, a variety of ground control issues have been encountered ranging from minor spalling to roof falls.

3.4.2 Purpose

The Ground Control Program provides the strategies for development and selection of the most applicable and efficient means of maintaining and monitoring the ground conditions of the WIPP underground to ensure safe and operational conditions. The selection of ground control fixtures is in accordance with 30 CFR 57, Subpart B, "Ground Control."

3.4.3 Scope

The program is continually evolving. Current associated activities include:

- Addressing ground control concerns and design and implementation of ground support systems on a case-by-case basis
- Installing and monitoring of small-scale and full-scale in-situ support systems for evaluation
- Identifying and/or developing new ground control technologies that have application to WIPP conditions
- Documenting and evaluating ground support system component failure
- Evaluating the effects of new mining and mine design changes on the effectiveness of installed ground support systems, proposed installations, and the stability of the excavation

3.4.4 Methods

Thorough evaluations of the ground conditions and support system performance throughout the facility will be performed annually. Some areas may be evaluated more frequently as conditions warrant. These evaluations will provide information necessary to address the near-term ground control needs and for long-term ground control planning.

Three basic options are available to address unstable ground conditions: (1) support the ground, (2) remove the ground, or (3) discontinue access. The first two options are engineering alternatives while the third option is an administrative decision. The ground control design criteria are based on long-term objectives, experience, performance of existing systems, laboratory and in-situ tests of selected ground control components and/or systems, numerical analysis, and site-specific geotechnical data. These criteria may be modified to accommodate technological advances, geologic conditions, or operational requirements.

Routine Activities

Ground support systems will be installed in accordance with approved written instructions. Monitoring of the geotechnical instruments that monitor the performance of the support systems will be performed routinely and carried out according to approved WIPP procedures.

Other Activities of the Ground Control Program

Activities which are in development, or which are not expected to be performed routinely, will be performed in accordance with industry standards or individual program plans that supplement this program plan.

4.0 QUALITY ASSURANCE

The WIPP Geotechnical Engineering programs are governed by the WID Quality Assurance Program Description. Steps to ensure quality will be incorporated, as needed, in the technical procedures used for geotechnical engineering activities. The Geotechnical Engineering manger, or assigned designee, is responsible for developing and maintaining this program plan and associated procedures.

4.1 Design Control

Items and processes will be designed using sound engineering/scientific principles and appropriate standards. Design work, including changes, will incorporate appropriate requirements such as general design criteria and design basis. Design interfaces will be identified and controlled. The adequacy of products will be verified by individuals or groups other than those who performed the work. Verification work will be completed before approval and implementation of the design.

4.2 Procurement

Procurement will be carried out in accordance with the appropriate policies and procedures. Technical requirements and services will be developed and specified in procurement documents. If deemed necessary, these documents will require suppliers to have an adequate quality assurance program to ensure that required characteristics are attained.

4.3 Instructions, Procedures and Drawings

Quality-affecting activities performed by, or on behalf of, the geotechnical engineering programs will be performed in accordance with written plans or approved procedures. WIPP general procedures will be used for procurement, document control, and quality assurance.

Technical procedures will be developed for routine quality-affecting functions. The procedures will include in-process and final quality controls and documentation requirements. The procedures will be as detailed as required and include, when applicable, quantitative or qualitative acceptance criteria to determine that activities have been satisfactorily accomplished. Procedures will be developed in accordance with existing WIPP procedures.

4.4 Document Control

Documents that prescribe processes, specify requirements, or establish design will be prepared, approved, issued, and controlled. Controls will ensure that the latest approved versions of procedures are used in performing geotechnical functions, and that obsolete materials are removed from work areas. The Geotechnical Engineering manager will identify the individuals responsible for the preparation, review, and approval of geotechnical engineering controlled documents.

4.5 Control of Purchased Material, Equipment, and Services

Measures will be taken, in accordance with current WIPP procurement policies and procedures, to ensure that procured items and services conform to specified requirements. These measures will generally include one or more of the following:

- Evaluation of the supplier□s capability to provide items or services, in accordance with requirements, including the previous record in providing similar products or services satisfactorily

- Evaluation of objective evidence of conformance, such as supplier submittals

- Examination and testing of items or services upon delivery

If it is determined that additional measures are required to ensure quality in a specific procurement, additional steps may be included in procurement documents and implemented by Geotechnical Engineering personnel and/or the Quality and Regulatory Assurance Department. These additional assurances may include source inspection and audits or surveillance at the suppliers□ facilities.

4.6 Identification and Control of Items

Measures will be used to ensure that only correct and accepted items are used at WIPP. All items that potentially affect the quality of the geotechnical engineering programs will be identified and controlled to ensure traceability and prevent the use of incorrect or defective items.

4.7 Test Control

Testing or experimental/monitoring activities will be in accordance with written plans or procedures that contain the following provisions, as applicable:

- Purpose, scope and/or definition
- Prerequisites such as calibrated instrumentation and supporting data; adequate test equipment and instrumentation, including accuracy requirements; completeness of item to be tested; suitable and controlled environmental conditions; and provisions for data collection and storage
- Instructions for performing the test
- Any mandatory inspection and/or hold points to be witnessed by WID or other designated representatives
- Acceptance and rejection criteria
- Methods of documenting or recording test data
- Requirements for qualified personnel
- Evaluation of test results by authorized personnel

Test or experimental/monitoring procedures prepared by other project participants (e.g., Sandia National Laboratories) used as WID procurement documents will be reviewed to ensure that the documents are complete and the tests described by the documents are adequate to determine that the involved equipment, systems, or structures are operationally acceptable.

4.8 Software Requirements

Computer program procurement, design, and testing activities that effect quality-related activities performed by WID or its suppliers will be accomplished in accordance with approved procedures (WP 16-1, WIPP Computer Protection Plan).

Test requirements and acceptance criteria will be specified, documented, and reviewed and will be based upon applicable software requirement, design, or other pertinent technical documents. Required tests, including verification, hardware integration, and in-use tests, will be controlled.

Testing of software will, at a minimum, verify the capability of the computer program to produce valid results for test problems encompassing the range of permitted usage defined by the program documentation. Testing will also be designed to identify and eliminate any serious defect that could, for example, cause a crash.

Depending on the complexity of the computer program being tested, requirements may range from a single test of the completed computer program to a series of tests performed at various stages of computer program development to verify correct translation between stages and proper working of individual modules. This will be followed by an overall computer program test.

Any software to be developed on site (by WID personnel or others) (i.e., noncommercial software) will follow the requirements of NQA-2.7, and shall include, at a minimum, a requirements document, a design document, a validation and verification plan, a software quality assurance plan, a testing plan and procedures, a configuration management plan, and appropriate user manuals. These will be reviewed and approved by appropriate WID personnel.

Regardless of the number of stages of testing performed, verification testing and validation will be of sufficient scope and depth to establish that software functional test requirements are satisfied and that the software produces a valid result for its intended function.

4.9 Control of Monitoring and Data Collection Equipment

Monitoring and data collection equipment will be controlled and calibrated in accordance with applicable WIPP controlled procedures. Results of calibrations, maintenance, and repair will be documented. Calibration records will identify the reference standard and the relationship to national standards or nationally accepted measurement systems.

Calibration reports and operability test data will be maintained by Geotechnical Engineering. Any out-of-tolerance condition will be evaluated for potential impact on the validity of data. Impact evaluation and corrective actions will be initiated per specific Geotechnical Engineering instructions.

4.10 Handling, Storage, and Shipping

Handling, storage, and shipping of items will be coordinated in accordance with established procedures or other specific documents. Geotechnical Engineering is responsible for storing, handling, and shipping rock core and other geologic samples.

4.11 Control of Nonconforming Conditions/Items

Conditions adverse to quality will be documented and classified in regard to their significance. Corrective action will be taken accordingly.

Equipment that does not conform to specified requirements will be controlled to prevent its use. Faulty items will be tagged and segregated. Repaired equipment will be subject to the original acceptance inspections and tests prior to use.

4.12 Corrective Actions

Conditions adverse to acceptable quality will be documented and reported in accordance with corrective action procedures and corrected as soon as practical. Immediate action will be taken to control work, and its results, performed under conditions adverse to acceptable quality in order to prevent degradation in quality.

The Geotechnical Engineering manager, or designee, will investigate any deficiencies in activities in accordance with approved procedures.

4.13 Records Management

Identification, preparation, collection, storage, maintenance, disposition, and permanent storage of records will be in accordance with approved WIPP procedures.

Generation of records will accurately reflect completed work and facility conditions and will comply with statutory or contractual requirements. The Geotechnical Engineering Records and Inventory and Disposition Schedule describes the classification and disposition for all records generated by the group. While in their custody, the records will be protected from loss and damage in accordance with approved WIPP procedures and they will coordinate with Project Records Services (PRS) for transfer of quality records to PRS. They are also responsible for the Core Library in the Core Storage Building where records will be maintained of all Core Library activities, including additions, removal of any material, any tests performed on the core, a record of people who examine the core on site, and any other alterations made to the core.

4.14 Audits and Independent Assessments

Planned periodic assessments will be conducted to measure management and item quality and process effectiveness, and to promote improvement. The organization performing independent assessments will have sufficient authority and freedom to carry out its responsibilities. Persons conducting assessments will be technically qualified and knowledgeable of the items and processes to be assessed.

4.15 Data Reduction and Verification

Computer programs, commercial data processing applications, and manual calculations that collect or manipulate/reduce data will be verified. Verification must be performed before the presentation of final results or their use in subsequent activities. If it becomes necessary to present or use unchecked results, transmittals and subsequent calculations will be marked "preliminary" until such time that the results are verified and determined to be correct.

5.0 REFERENCES

Title 30 CFR ▯ 57, Subpart B, "Ground Control"
Title 40 CFR ▯ 194, Section 42, "Monitoring"
WP 13-1, Quality Assurance Program Description
WP 16-1, WIPP Computer Protection Plan

DOE/WIPP 99-2300

Geotechnical Analysis Report for July 1997–June 1998

March 1999

Waste Isolation Pilot Plant

CUB 194-A-20

FOREWORD AND ACKNOWLEDGMENTS

This report contains an assessment of the geotechnical status of the Waste Isolation Pilot Plant. During the excavation of the principal underground access and experimental areas, that status was reported quarterly. Since 1987, when underground activity slowed down, reports have been published annually. This report presents and analyzes data collected from July 1, 1997, to June 30, 1998.

This Geotechnical Analysis Report was written to meet the needs of several audiences. It focuses on the geotechnical performance of the various components of the underground facility, including the shafts, shaft stations, access drifts, and waste disposal areas. The results of excavation effects investigations, stratigraphic mapping, and other geologic studies are also included. The report compares the geotechnical performance of the repository to the design criteria. It describes the techniques that were used to acquire the data and the performance history of the instruments. The depth and breadth of the evaluation of the different components of the underground facility vary according to the types and quantities of data available and the complexity of the recorded geotechnical responses. Graphic documentation of data and tabular documentation of instrument history can be provided upon request.

This Geotechnical Analysis Report was prepared by Westinghouse Electric Company, Waste Isolation Division, for the U.S. Department of Energy (DOE), Carlsbad Area Office, Carlsbad, New Mexico. Work was supported by the DOE under Contract No. DE-AC04-86AL31950.

The public can acquire the document through the following:

National Technical Information Service
U.S. Department of Commerce
5285 Port Royal Road
Springfield, VA 22161

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List of Acronyms and Abbreviations

b.p.	before present
CAO	Carlsbad Area Office
CH	contact handled
cm	centimeter(s)
DOE	U.S. Department of Energy
EPA	U.S. Environmental Protection Agency
ft	foot (feet)
GAR	Geotechnical Analysis Report
GIS	geotechnical information system
in.	inch(es)
KPa	kilopascal(s)
lb	pound(s)
m	meter(s)
Ma	millions of years
MB	marker bed
OMB	orange marker bed
psi	pound(s) per square inch
SDD	system design description
SNL/NM	Sandia National Laboratories/New Mexico
SPDV	Site Preliminary Design Validation
TRU	transuranic
WIPP	Waste Isolation Pilot Plant
yr	year(s)

1.0 Introduction

This Geotechnical Analysis Report (GAR) presents and interprets the geotechnical data from the underground excavations at the Waste Isolation Pilot Plant (WIPP). The data, which are obtained as part of a regular monitoring program, are used to characterize conditions, to compare actual performance to the design assumptions, and to evaluate and forecast the performance of the underground excavations during operations.

GARs have been available to the public since 1983. During the Site and Preliminary Design Validation (SPDV) Program, the architect/engineer for the project produced these reports on a quarterly basis to document the geomechanical performance during and immediately after excavation of the underground facility. Since the completion of the construction phase of the project in 1987, the management and operating contractor for the facility has prepared these reports annually. This report describes the performance and condition of selected areas from July 1, 1997, to June 30, 1998. It is divided into nine chapters. The remainder of Chapter 1.0 provides background information on the WIPP, its mission, and the purpose and scope of the geomechanical monitoring program. Chapter 2.0 describes the local and regional geology of the WIPP site. Chapters 3.0 and 4.0 describe the geomechanical instrumentation located in the shafts and shaft stations, present the data collected by that instrumentation, and provide interpretation of these data. Chapters 5.0, 6.0, and 7.0 present the results of geomechanical monitoring in the three main portions of the WIPP underground facility (Northern Experimental Area, the access drifts, and the Waste Disposal Area). Chapter 8.0 discusses the results of the Geoscience Program, which includes geologic core mapping, fracture mapping, and borehole observations. Chapter 9.0 summarizes the results of the geomechanical monitoring and compares the current excavation performance to the design requirements.

1.1 Location and Description

The WIPP is located in southeastern New Mexico, 42 kilometers (26 miles) east of Carlsbad (Figure 1-1). The surface facilities were built on the flat to gently rolling hills that are characteristic of the Los Medaños area. The underground facility is being excavated approximately 655 meters (m) (2,150 feet [ft]) beneath the surface in the Salado Formation. Figure 1-2 shows a plan view of the current underground configuration of the WIPP.

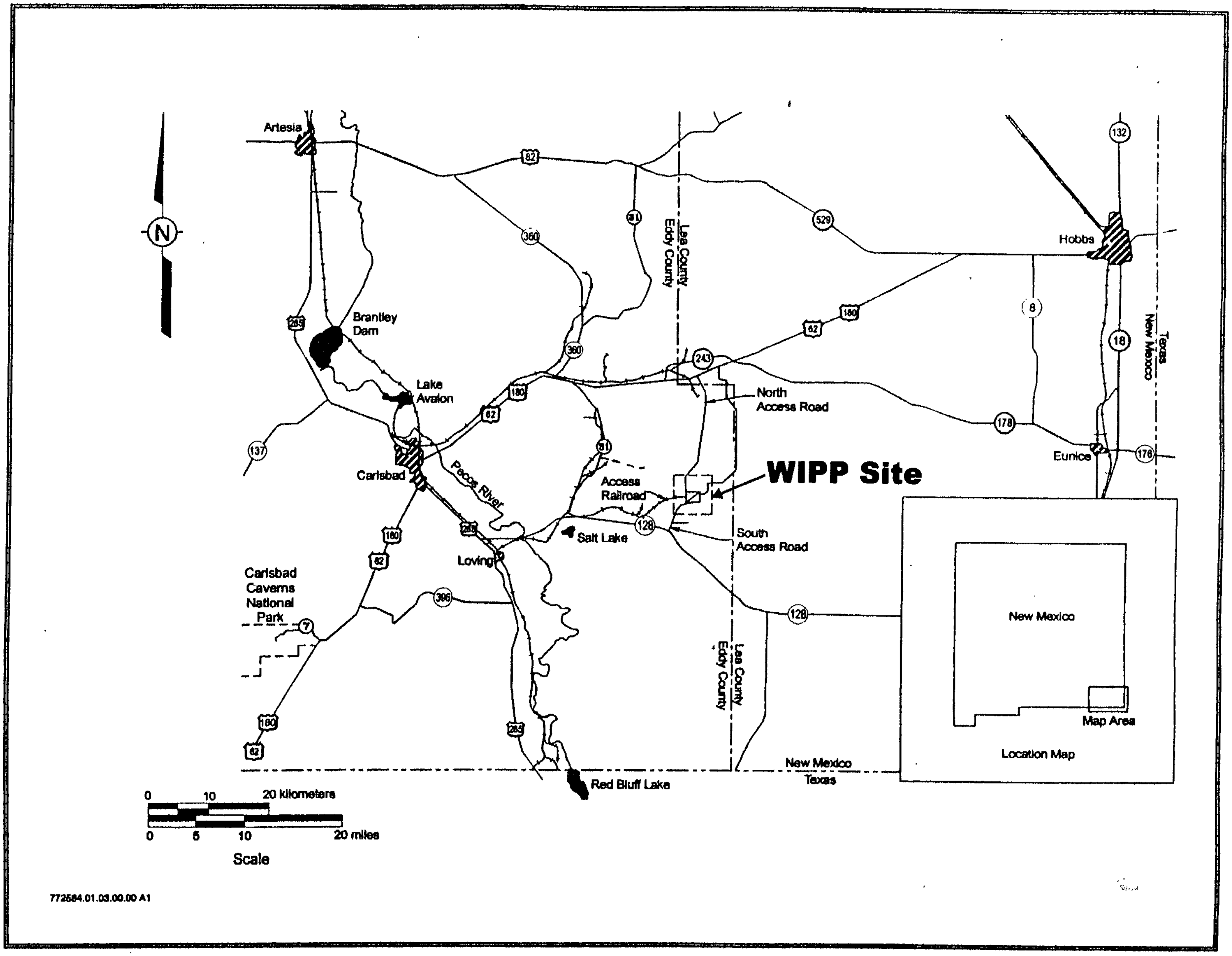


Figure 1-1
WIPP Location

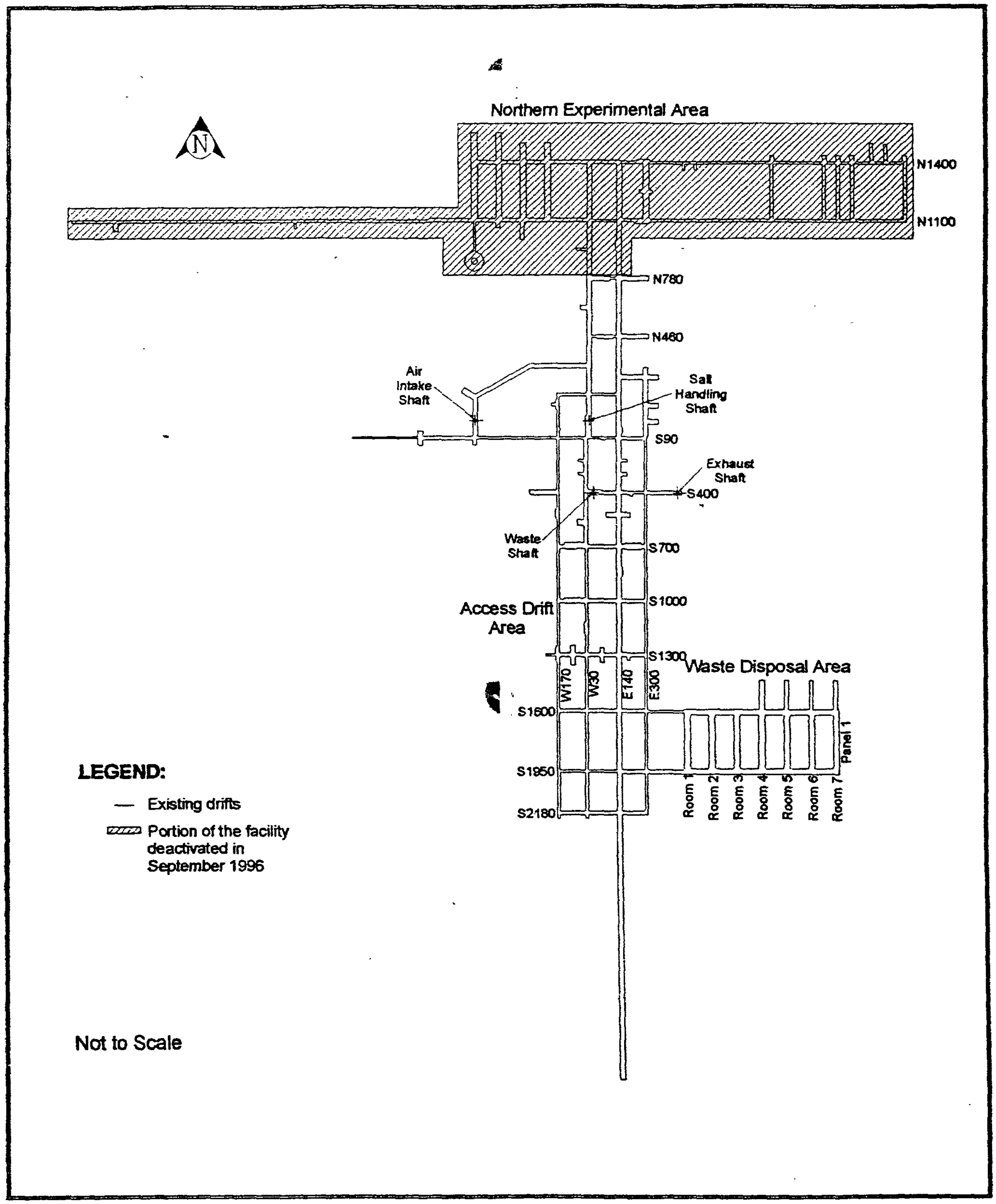


Figure 1-2
Current Underground Configuration

1.2 Mission

In 1979 Congress authorized the WIPP (Public Law 96-164) to provide ". . . a research and development facility to demonstrate the safe disposal of radioactive wastes resulting from the defense activities and programs of the United States exempted from regulation by the Nuclear Regulatory Commission." The WIPP is intended to receive, handle, and permanently dispose of transuranic (TRU) waste and TRU mixed waste. To fulfill this mission, the U.S. Department of Energy (DOE) constructed a full-scale facility to demonstrate both technical and operational principles of the permanent disposal of TRU and TRU mixed wastes. Technical aspects are those concerned with the design, construction, and performance of the subsurface excavations. Operational aspects refer to the receiving, handling, and emplacement of TRU wastes in the facility. The facility was also used for in situ studies and experiments without the use of radioactive waste. These studies and experiments have been completed.

1.3 Development Status

To fulfill its mission, the DOE developed the WIPP in a phased manner. The goal of the SPDV phase, begun in 1980, was to characterize the site and obtain in situ geotechnical data from underground excavations in order to determine whether site characteristics and the in situ conditions were suitable for a permanent disposal facility. During this phase, the Salt Handling Shaft, a ventilation shaft, a drift to the southernmost extent of the proposed waste disposal area, a four-room experimental panel, and access drifts were excavated. Surface-based geological and hydrological investigations were also conducted. The data obtained from the SPDV investigations were reported in the "Summary of the Results of the Evaluation of the WIPP Site and Preliminary Design Validation Program" (DOE, 1983).

Based upon the favorable results of the SPDV investigations, additional activities were initiated in 1983. These included the construction of surface structures, conversion of the ventilation shaft for use as the waste shaft, excavation of the exhaust shaft, development of additional access drifts to the Waste Disposal Area, excavation of the air intake shaft, and excavation of additional experimental rooms to support research and development activities. Geotechnical data acquired during this phase were used to evaluate the performance of the excavations in the context of established design criteria (DOE, 1984). Results of these evaluations were reported in Geotechnical Field Data and Analysis Reports (DOE, 1985; DOE, 1986a) and were summarized in the Design Validation Final Report (DOE, 1986b).

The Design Validation Final Report concluded that the facility, including waste disposal areas, could be developed and operated to fulfill the long-term mission of the WIPP (DOE, 1986b).

However, some modifications to the reference design were proposed so that the requirements could be met for the anticipated life of the waste disposal rooms and the demonstration phase while the waste remained retrievable.

The original design for the waste disposal rooms allowed for a relatively short time in which to mine the salt and emplace waste. Each panel, consisting of seven disposal rooms, was scheduled to be mined, filled with waste containers, and closed in fewer than 5 years. Field studies, as part of the SPDV Program, proved that unsupported openings of a typical disposal room configuration at the WIPP would remain stable and safe during the 5-year period following excavation, and that closure from creep would not affect the operation of large equipment during that time. The information from these studies validated the design of underground openings to accommodate safely the permanent disposal of waste under routine operating conditions.

Panel 1 was intended to receive waste for an initial operations demonstration and pilot plant phase that was scheduled to start in October 1988. This original plan was to place drums of contact-handled (CH) TRU waste in the disposal rooms for a period of up to 5 years. The waste in the disposal rooms would not be easily accessible, but the option to reenter would be maintained so that the waste could be removed, if required. To maintain roof stability for possible reentry, rockbolts were installed in the rooms.

The operations demonstration was deferred, and the pilot plant phase was modified to use CH TRU waste in bin-scale tests in Room 1, Panel 1. The purpose of this program, referred to as the test phase, was to investigate whether waste disposal at the WIPP could be conducted in compliance with environmental standards and regulations. The decision to conduct these bin-scale tests in Room 1, Panel 1, was made in June 1989, when it was anticipated that the initial shipment of waste would be received in 1990. An additional 7 years was required of the room for the on-site bin-scale tests beginning in July 1991. These added requirements led to more stringent criteria for roof support systems. In late 1993, however, the DOE decided to conduct the test phase off site and established 1998 as a new date for first receipt of waste. Additional delays in obtaining a permit from the New Mexico Environment Department for disposal of the hazardous chemical components of waste have postponed the receipt of waste to 1999. Despite these delays Panel 1 continues to be maintained and monitored and will be used for waste disposal.

In October 1996, the DOE submitted to the U.S. Environmental Protection Agency (EPA) a compliance certification application in accordance with Title 40, Section 191, of the Code of Federal Regulations, "Compliance Certification Application," which addressed the long-term

(10,000-year) performance criterion for the disposal system. In June 1998 after a period of public comment, the EPA issued final certification that allows for the receipt of TRU waste at the WIPP. During this review period, the DOE Carlsbad Area Office (CAO) completed the WIPP Operational Readiness Review, which is required before the startup of a nuclear waste repository. As a result of the review, the CAO notified Energy Secretary Federico Peña on April 1, 1998, that the WIPP is operationally ready to receive waste.

1.4 Purpose and Scope of Geomechanical Monitoring Program

The purpose of the geomechanical monitoring program is to obtain in situ data to support the following:

- Early detection of conditions that could compromise operational safety
- Evaluation of room closure
- Design modifications and remedial actions
- Interpretation of the in situ behavior of underground openings, for comparison with established design criteria.

The geomechanical instrumentation system (GIS) provides data that are collected, processed, and stored for analysis. This section briefly describes the major components of the GIS.

1.4.1 Instrumentation

Instruments installed for measuring the geomechanical response of the shafts, drifts, and other underground openings include convergence points, convergence meters, extensometers, rockbolt load cells, pressure cells, strain gauges, piezometers, and joint meters. Table 1-1 lists a summary of the geomechanical instrumentation specifications.

1.4.2 Data Acquisition

The individual geomechanical instruments are read either manually using portable devices or remotely by electronically polling the stations from the surface. Remotely read instruments are connected to one of the dataloggers located underground, and readings are collected by initiating the appropriate polling routine. Upon completion of a verification process, the data are transferred to a computer database. The manually read devices are taken to the instrument locations underground and the data are recorded on a data sheet and later entered into database files, with the remotely acquired data.

Table 1-1

Geomechanical Instrumentation System

Instrument Type	Measures	Range[a]	Resolution[a]
Sonic probe borehole extensometer	Cumulative deformation	0–2 in.	0.001 in.
Convergence points	Cumulative deformation	2–50 ft	0.001 in.
Wire convergence meters	Cumulative deformation	2–50 ft	0.001 in.
Sonic probe convergence meters	Cumulative deformation	2–50 ft	0.001 in.
Embedded strain gauges	Cumulative strain	0–3000 μin./in.	1 μin./in.
Spot-welded strain gauges	Cumulative strain	0–2500 μin./in.	1 μin./in.
Rockbolt load cells	Load	0–50 tons	40 lb
Earth pressure cells	Pressure	0–1000 psi	1 psi
Piezometers	Fluid pressure	0–500 psi	0.5 psi
Joint Meters	Cumulative deformation	0–4 in.	0.001 in.
Vibrating wire borehole extensometer	Cumulative deformation	0–4 in.	0.001 in.
Borehole lateral displacement sensor	Lateral offset	0–3 in.	0.003 in.
Linear potentiometric borehole extensometer	Cumulative deformation	0–6 in.	0.001 in.

[a] Manual read out boxes for the instruments were manufactured to output measurements in English units. Range and resolution measurement units have not been converted to metric units. Measurements from these instruments <u>have</u> been converted for presentation elsewhere in this report.

ft = foot (feet).
in. = inch(es).
μin. = microinch(es).
psi = pound(s) per square inch.
lb = pound(s).

The underground data acquisition system consists of instruments, polling devices, and a communications network. One or more instruments are connected to a polling device. The polling devices are installed in boxes or cabinets near the location of the instrument to facilitate queries of each individual instrument. The polling devices are connected by datalink cables and modems to a surface computer.

Whether acquired manually or remotely, geomechanical data are entered into the database files of the GIS data processing system. The data processing system consists of computer programs that are used to enter, reduce, and transfer the data to permanent storage files. Additional routines allow access to these permanent storage files for numerical analysis, tabular reporting, and graphical plotting. Copies of the instrumentation database and data plots are available upon request[1].

1.4.3 Data Evaluation

Closure measurements are acquired manually from convergence point anchors and remotely from convergence meters. The plots are presented as ground displacement monitored over time and plotted as either surface displacement or closure versus time.

Extensometers provide relative displacement data acquired from sensors installed in a borehole. The displacement is the measure of movement at various depths in the rock strata intercepted by the extensometer borehole. Displacement is measured relative to a fixed point. Extensometers consist of rods that are anchored in a borehole at various depths. The deepest anchor is fixed in what is assumed to be undisturbed ground and is used as the reference point. Typically, the plots will show greater relative ground movement near the collar (i.e., the opening of the hole).

Rockbolt load cells are used to determine the bolt loading. Plots show load versus time for each instrumented bolt.

Earth pressure cells and strain gauges are used to determine the stresses and deformations in and around the shaft liners, and data are depicted in time-based plots. These instruments monitor whether there is any stress buildup in the shaft lining systems.

Piezometers used to measure the gauge pressure of groundwater are installed in the shafts at varying elevations to monitor the hydraulic head acting on the shaft liners. Data from piezometers are plotted as pressure versus time. Joint meters installed perpendicular to a crack monitor the displacement of the crack with time. Data from these are typically presented as displacement versus time.

1.4.4 Data Errors

As described above, GIS data are processed through a comprehensive database management system. Whether acquired manually or remotely, GIS data are processed and permanently stored

[1] Instrumentation data and data plots are available in "Geotechnical Analysis Report for July 1997–June 1998 Supporting Data." This document is available upon request from Westinghouse Electric Company, Waste Isolation Division. See Foreword and Acknowledgments for details and addresses.

according to approved procedures. On occasion, erroneous readings can occur. There are several possible explanations for erroneous readings including the following:

- The measuring device was misread.
- The reading was recorded incorrectly.
- The measuring device was not functioning within specifications.

When a reading is believed to be erroneous, an immediate evaluation of the previous readings is performed, and a second reading is collected. If the second reading falls in line with the instrument trend, the first reading is discarded and the second reading is entered in the database. If the second reading and subsequent readings remain out of the instrument trend, the ground conditions in the vicinity of the instrument are assessed to determine the reason for the discrepancy. In addition, reading frequency may be increased. This process to correct erroneous readings is documented and filed for future reference.

2.0 Geology

This chapter will acquaint the reader with the stratigraphy of the WIPP region and the facility stratigraphy. Readers desiring further geologic information can consult one of the references cited in the Selected Bibliography, Section 10.2. In particular, the "Geological Characterization Report, WIPP Site, Southeastern New Mexico" (Powers et al., 1978) was developed as a source document on the geology of the WIPP site for individuals, groups, or agencies seeking basic information on geologic history, hydrology, geochemistry, or detailed information, such as physical and chemical properties of repository rocks. A more recent survey of WIPP stratigraphy is included in Holt and Powers (1990).

2.1 Regional Stratigraphy

The stratigraphy in the vicinity of the WIPP site includes rocks and sediments of Permian (286 to 245 million years ago [Ma]), Triassic (245 to 208 Ma), and Quaternary (1.6 Ma to present) ages. The generalized descriptions of formations provided in this section are given in order of deposition (oldest to youngest), beginning with the Castile Formation (Figure 2-1).

The Permian system in the United States is divided into four series. The last of these, the Ochoan Series, contains the host rock in which the WIPP facility is located. The Ochoan Series is of mostly marine origin and consists of four formations: three evaporite formations (the Castile, the Salado, and the Rustler) and one redbed formation (the Dewey Lake). The Ochoan evaporites overlie marine limestones and sandstones of the Guadalupian Series (Delaware Mountain Group). The younger redbeds represent a transition from the lower evaporite deposition to fluvial deposition on a broad, low-relief, fluvial plain. Fluvial deposits of the Triassic and Quaternary periods complete the stratigraphic column.

2.1.1 Castile Formation

The Castile Formation, lowermost of the four Ochoan formations, is approximately 380 m (1,250 ft) thick in the WIPP vicinity. Lithologically, the Castile is the least complex of the evaporite formations and is composed chiefly of interbedded anhydrite and halite, with limestone present in minor amounts.

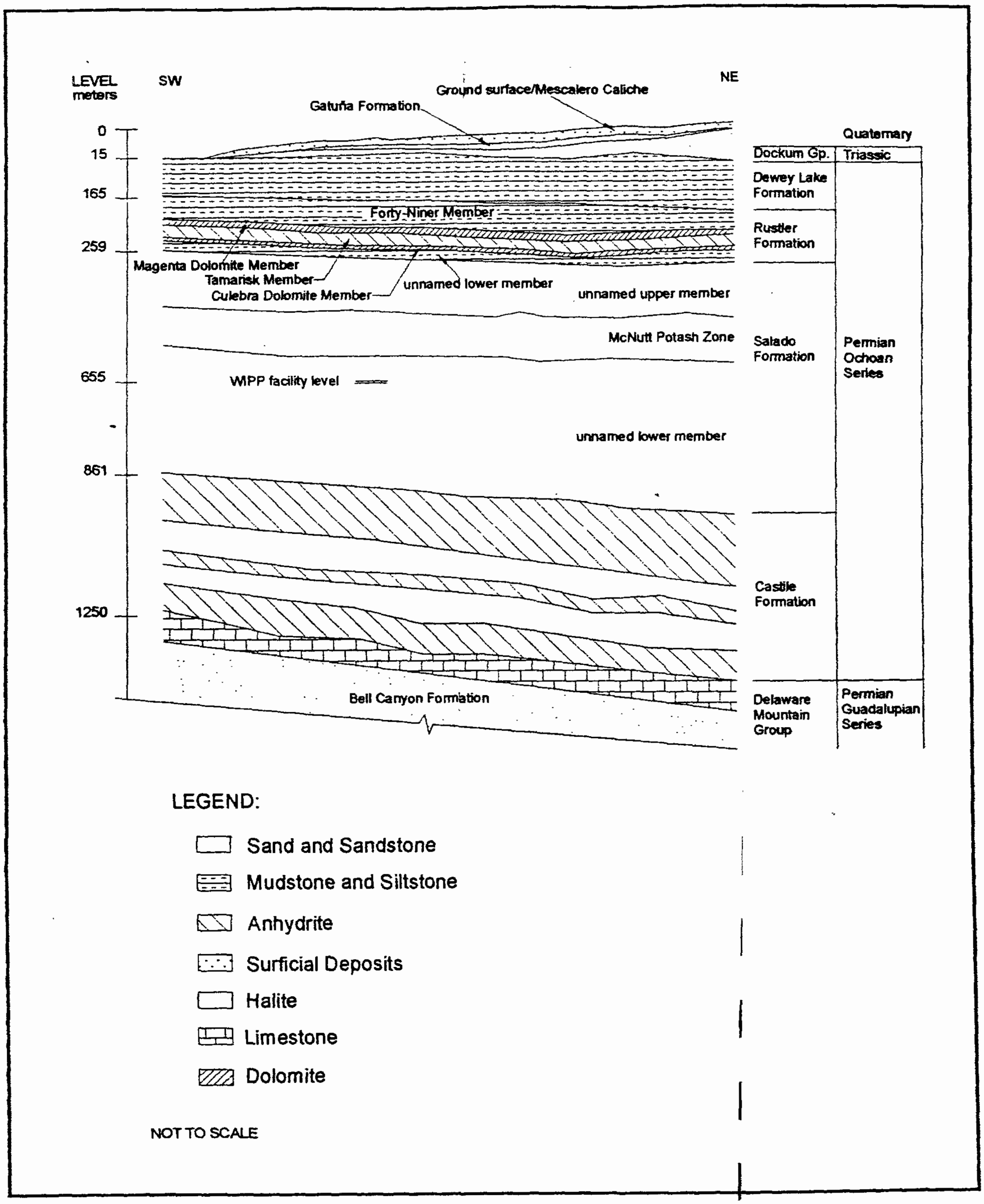


Figure 2-1
Regional Geology

2.1.2 Salado Formation

The Salado Formation comprises nearly 610 m (2,000 ft) of evaporites (primarily halite). The formation is subdivided into three informal members, the unnamed lower member, the McNutt potash zone, and the unnamed upper member. Each member contains similar amounts of halite, anhydrite, and polyhalite and is differentiated on the basis of soluble potassium and magnesium-bearing minerals. The WIPP disposal horizon is located within the unnamed lower member, 655 m (2,150 ft) below the surface.

2.1.3 Rustler Formation

The Rustler Formation is the uppermost of the three Ochoan evaporite formations and contains the largest proportion of clastic material of the three. The Rustler is subdivided into five members as follows (from the base): an unnamed lower member, the Culebra Dolomite Member, the Tamarisk Member, the Magenta Dolomite Member, and the Forty-niner Member.

In the vicinity of the WIPP site the Rustler is about 95 m (310 ft) thick and thickens to the east. The lower portion (the unnamed lower member) contains primarily fine sandstone to mudstone with lesser amounts of anhydrite, polyhalite, and halite. Bedded and burrowed siliciclastic sedimentary rocks with cross-bedding and fossil remains signify the transition from the strongly evaporitic environments of the Salado to the brackish lagoonal environments of the Rustler (Holt and Powers, 1990).

The upper portion of the Rustler contains interbeds of anhydrite, dolomite, and mudstone. The Culebra Dolomite member is generally brown, finely crystalline and locally argillaceous. The Culebra contains rare to abundant vugs with variable gypsum and anhydrite filling and is the most transmissive hydrologic unit within the Rustler. The Tamarisk Member consists of lower and upper sulfate units separated by a unit that varies laterally from mudstone to mainly halite. The Magenta Dolomite Member is a gypsiferous dolomite with abundant primary sedimentary structures and well-developed algal features. The Forty-niner Member is a mudstone that displays sedimentary features and bedding relationships indicating sedimentary transport and deposition on a mudflat. East of the site area, halite correlates with the mudstone. The Culebra and Magenta Dolomite members are persistent and serve as important marker units.

2.1.4 Dewey Lake Redbeds

The Dewey Lake Redbeds are the uppermost of the Ochoan Series formations in the WIPP vicinity. Within the series, the Dewey Lake represents a transition from the lower marine-influenced evaporite deposition to fluvial deposition on a broad, low-relief, fluvial plain. The redbeds, about 145 m (475 ft) thick, consist of predominantly reddish-brown interbedded fine-grained sandstone, siltstone, and claystone. The formation is differentiated from other formations by its lithology and distinctive color (both of which are remarkably uniform), and sedimentary structures, including horizontal- and cross-laminae and ripple marks. The redbeds also contain locally abundant greenish-gray reduction spots and gypsum-filled fractures. The formation thickens from west to east due to eastward dips and erosion to the west.

2.1.5 Dockum Group

The Dockum Group consists of fine-grained floodplain sediments and coarse alluvial debris of Triassic age. At the WIPP site, the Dockum Group pinches out near the center of the site and thickens eastward as an erosional wedge. Local subdivisions of the Dockum Group are the Santa Rosa Sandstone and the Chinle Formation, however, only the Santa Rosa occurs in the vicinity of the site. The Santa Rosa consists primarily of poorly sorted sandstone with conglomerate lenses and thin mudstone partings and contains impressions and remnants of fossils. These rocks have more variegated hues than the underlying uniformly colored Dewey Lake.

2.1.6 Gatuña Formation, Mescalero Caliche, and Surficial Sediments

Quaternary Period deposits include the Gatuña Formation, Mescalero Caliche, and surficial sediments. The Gatuña Formation (ranging in age from approximately 13 Ma to 600,000 years before present [b.p.] [Powers and Holt, 1993]) is a stream-laid deposit overlying the Dockum Group in the WIPP vicinity. At the site center the formation consists of about 4 m (13 ft) of poorly consolidated sand, gravel, and silty clay. The Gatuña Formation is light red and mottled with dark stains. The unit contains abundant calcium carbonate but is poorly cemented. Sedimentary structures are abundant (Powers and Holt, 1993, 1995).

The Mescalero Caliche (approximately 500,000 years b.p.) is about 1.2 m (4 ft) thick in the WIPP vicinity. The Mescalero is a hard, resistant soil horizon that lies beneath a cover of wind-blown sand. The horizon is petrocalcic, or very strongly cemented with calcium carbonate. Petrocalcic horizons form slowly beneath a stable landscape at the average depth of infiltration of soil moisture and are an indicator of stability and integrity of the land surface. Many of the surface buildings at the WIPP are founded on top of the Mescalero Caliche.

Surficial sediments include sandy soils developed from eolian material and active dune areas. The Berino Series (a soil type) covers about 50 percent of the site and consists of deep sandy soils that developed from wind-worked material of mixed origin. Based on sample analyses, the Berino soil from the WIPP site formed 330,000 ± 75,000 years ago.

2.2 Underground Facility Stratigraphy

The WIPP disposal horizon lies in the approximate center of the Salado Formation. The Salado was deposited in a shallow saline lagoon environment, which progressed through numerous inundation and desiccation cycles that are reflected in the formation. An "ideal" cycle progresses upward as follows: a basal layer consisting predominantly of claystone, followed by a layer of sulfate, which is in turn followed by a layer of halite. The entire sequence is capped by a bed of argillaceous (clay-rich) halite accumulated during a period of mainly subaerial exposure.

A regional system used for numbering the more significant sulfate beds within the Salado designates these beds as marker beds (MB) 100 (near the top of the formation) to MB144 (near the base). The repository's experimental area and disposal area horizons are located between MB139 and MB138 (Figure 2-2) within a sequence of laterally continuous depositional cycles as described above. Within this sequence, layers of clay and anhydrite that are locally designated (as shown) can have a significant impact on the geomechanical performance of the excavations. Clay layers provide surfaces along which slip and separation can occur, whereas anhydrite acts as a brittle unit that does not deform plastically.

2.2.1 Disposal Horizon Stratigraphy

Most underground excavations are located within the disposal horizon (see Figure 2-2). In this horizon, the Orange Marker Bed (OMB) typically occurs near mid-rib. The OMB is a laterally consistent unit of moderately to light reddish-orange halite, typically about 15 centimeters (cm) (6 inches [in.]) thick that is used as a point of reference for disposal area excavation.

MB139 typically lies about 1.5 m (5 ft) below the excavation floor. MB139 is a 50- to 80-cm (20 to 32 in.) thick layer of polyhalitic anhydrite. The top of the anhydrite undulates up to 38 cm (15 in.) while the bottom is subhorizontal and is underlain by clay E. Above MB139 is a unit of halite which terminates at the base of the OMB. Within this unit, polyhalite is locally abundant and decreases upward, while argillaceous material increases upward.

Above the OMB, a thin sequence of argillaceous halite gives way to a thick sequence of clear halite that becomes increasingly argillaceous upward and is capped by clay F. Clay F occurs as a

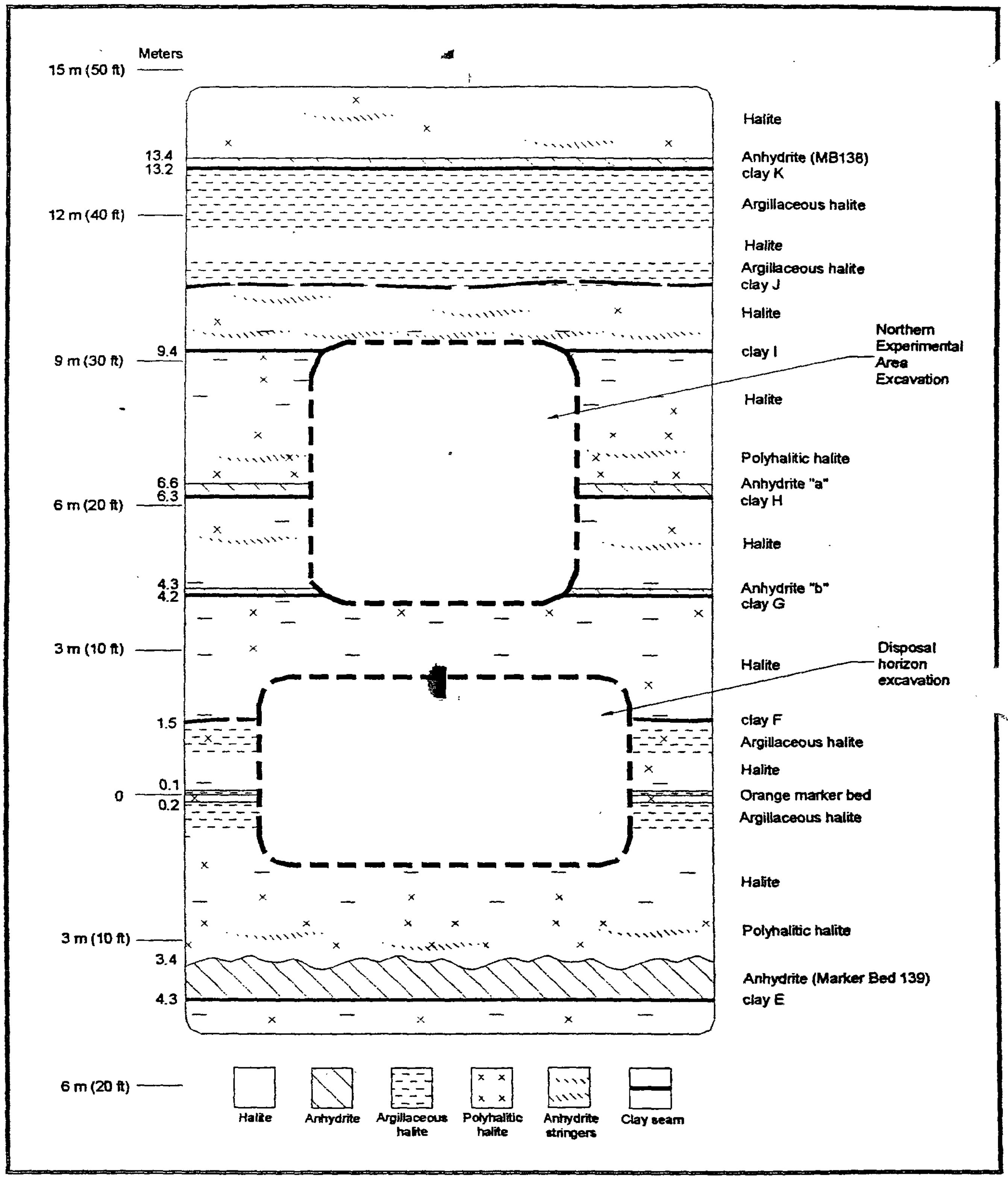


Figure 2-2
Repository Level Stratigraphy

thin layer occasionally interrupted by partings and breaks and is readily visible in the upper ribs of disposal horizon excavations, usually about 60 cm (24 in.) below the roof.

Above clay F, another sequence of halite begins that, as in lower sequences, becomes increasingly argillaceous upward. This sequence terminates at the clay G/Anhydrite "b" interface, about 2 m (6.5 ft) above the roof of disposal horizon excavations forming the first roof beam. Another depositional sequence begins with Anhydrite "b" and progresses upward to the clay H/Anhydrite "a" interface, typically about 4 m (13 ft) above the roof.

2.2.2 Experimental Area Stratigraphy

Some experimental excavations, located in the eastern wing of the Northern Experimental Area (now deactivated and closed), lie at a higher stratigraphic level than the disposal excavations. These excavations typically have floors excavated at Anhydrite "b" and roofs that lie at (or a few feet above) Anhydrite "a", or at clay I. As in the lower units, the halite intervals between the clay seams/anhydrite beds contain relatively pure halite that becomes increasingly argillaceous upward.

Above clay I, two more halite intervals complete the underground facility stratigraphy. Clay J at the top of the first of these intervals may occur as a distinct seam or merely an argillaceous zone. Clay K tops the second interval and is overlain by anhydrite MB138.

3.0 Performance of Shafts and Keys

Four shafts connect the surface with the WIPP underground facility. The four shafts are the Salt Handling Shaft which is used for removing excavated salt from the underground, the Waste Shaft which is the primary shaft for transporting men and materials between the surface and the underground and will be used for transporting the transuranic waste to the underground disposal area, the Exhaust Shaft used to exhaust the ventilation air from the underground, and the Air Intake Shaft which is the source of fresh air ventilation to the underground. This chapter describes the geomechanical performance of these shafts.

3.1 Salt Handling Shaft

The first construction activity undertaken during the SPDV Program was the excavation of the Exploratory Shaft. This shaft was subsequently referred to as the Construction and Salt Handling Shaft and is currently designated the Salt Handling Shaft (see Figure 1-2). The shaft was drilled from July 4 to October 24, 1981, and geologic mapping was conducted in the spring of 1982 (DOE, 1983). Figure 3-1 presents the stratigraphy at the Salt Handling Shaft.

The Salt Handling Shaft is lined with steel casing and has a 3-m (10-ft) inside diameter from the ground surface to the shaft key at a depth of 258 m (846 ft). The steel liner has a thickness of 1.6 cm (0.62 in.) at the top, increasing with depth to a thickness of 3.8 cm (1.5 in.), including external stiffener rings, at the key. Cement grout is placed between the liner and rock face. The 3-m (10-ft) diameter extends through the concrete shaft key to a depth of 268 m (880 ft). The shaft key is an 11.4 m- (37.5 ft-)long reinforced-concrete structure at the base of the steel liner. The shaft from the key to the bottom of the shaft, at a depth of 700 m (2,298 ft) has a nominal diameter of 4 m (12 ft). Wire mesh anchored by rockbolts is installed in this portion as a safety screen to contain rock fragments that may become detached. The shaft extends approximately 43 m (140 ft) below the facility horizon in order to accommodate the skip loading equipment and to act as a sump.

3.1.1 Shaft Observations

Underground operations personnel conduct weekly visual shaft inspections. These inspections are performed principally to assess the condition of the hoisting and mechanical systems, but they also include examining the shaft walls for water seepage, loose rock, or sloughing. The visual shaft inspections during this reporting period found that the Salt Handling Shaft was in

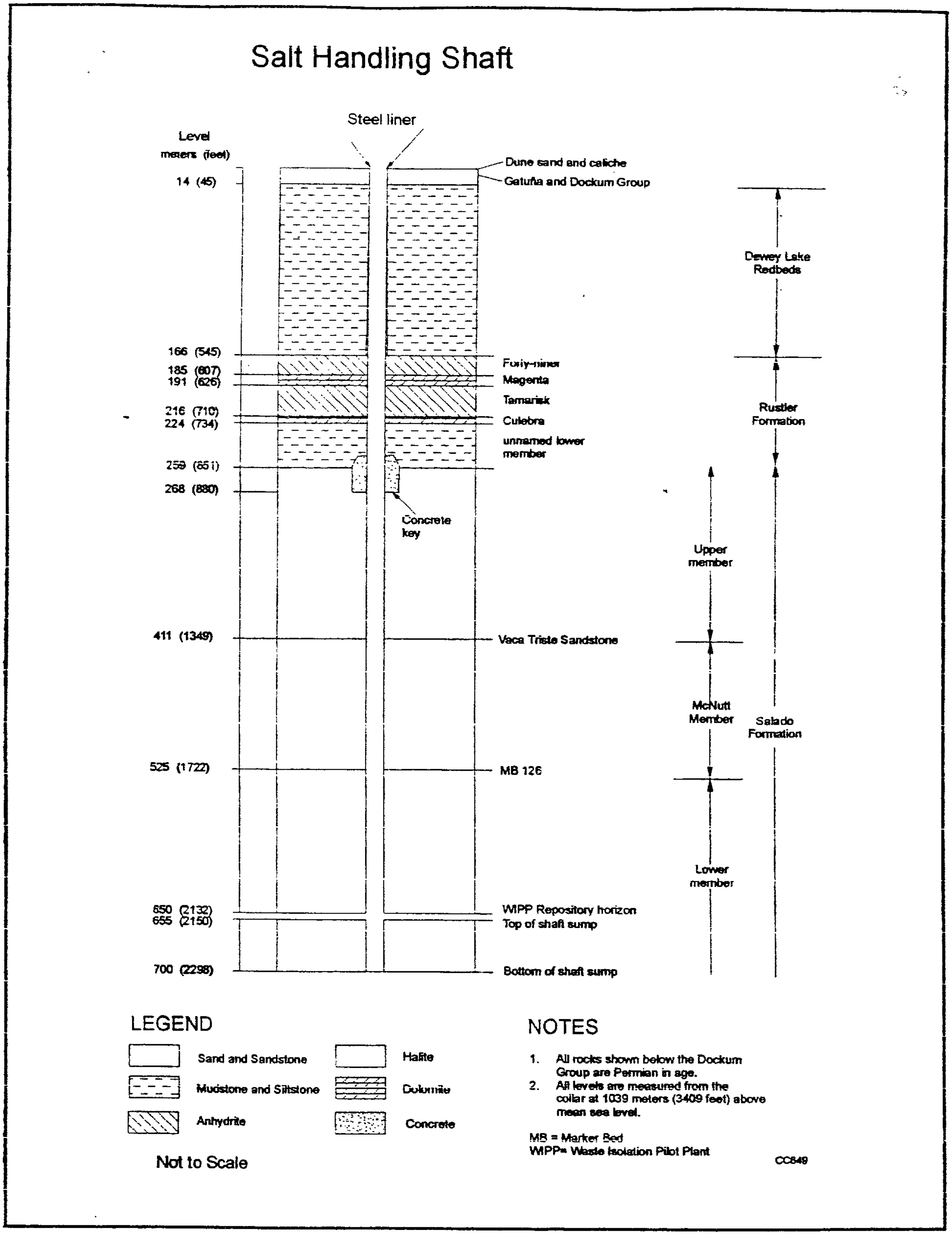


Figure 3-1
Salt Handling Shaft Stratigraphy

satisfactory condition. Some ground control activities were performed in the Salt Handling Shaft during this reporting period. Table 3-1 summarizes these activities.

Table 3-1
Summary of Ground Control Activities in the Salt Handling Shaft
July 1, 1997 through June 30, 1998

Date Completed	Work Performed
November 1997	Completed scaling of shaft walls near keyway
April 1998	Completed scaling and realigning of steel sets and wooden guides due to salt creep in the shaft.

3.1.2 Instrumentation

Geomechanical instruments (extensometers, piezometers, and radial convergence points) were installed at various levels in the Salt Handling Shaft during April and July of 1982 (Figure 3-2). In the shaft key, instruments included strain gages, pressure cells, and piezometers (Figure 3-3).

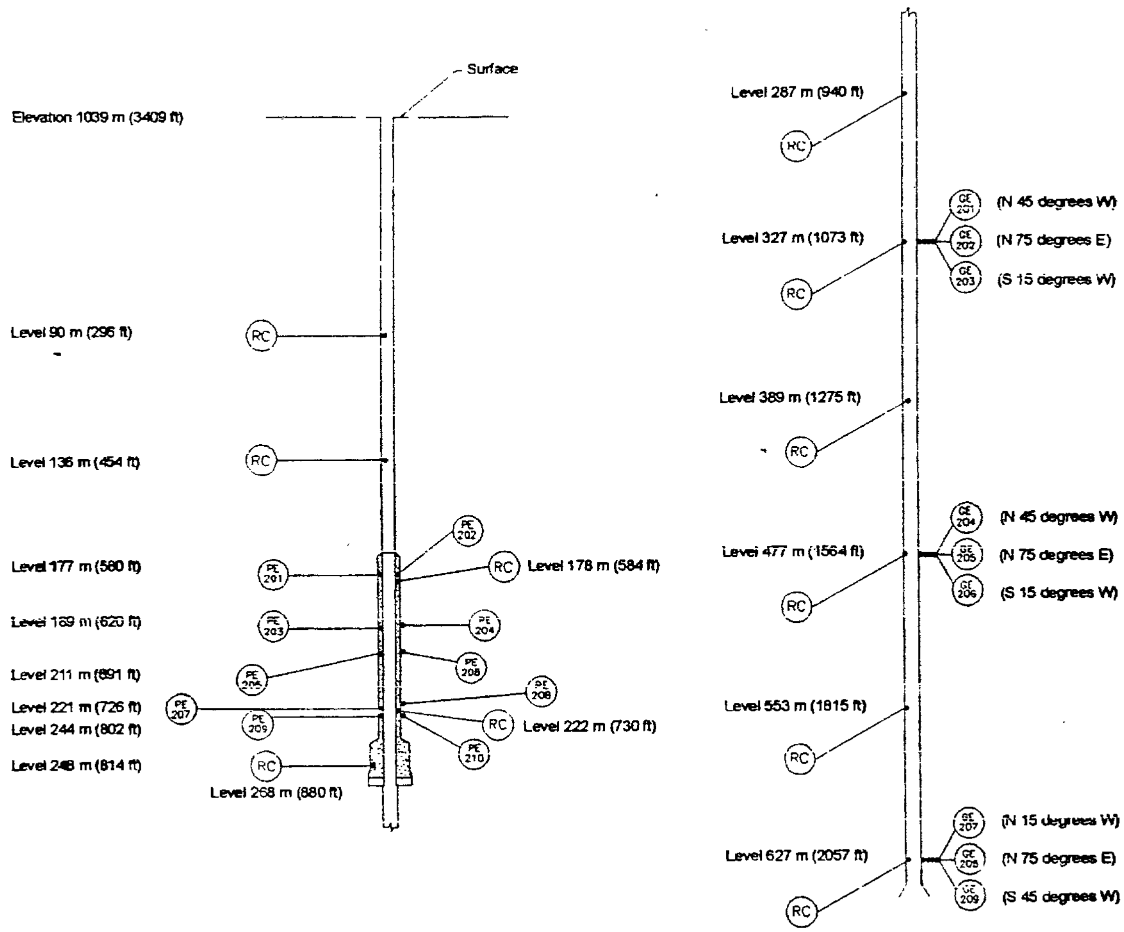
Currently, only one of the original nine extensometers (37X-GE-00209 located at level 627 m [2,057 ft]) remains functional. Data from this extensometer indicate that the collar displacement on the date of the last reading, April 1, 1998, was 1.86 cm (0.731 in.). The other eight extensometers have not functioned properly since 1993.

All 12 piezometers continue to provide data. The fluid pressures recorded at the end of this reporting period range from approximately 600 kilopascals (KPa) (85 pounds per square in. [psi]) at the 177-m (580-ft) level in the Forty-niner member to over 1,000 KPa (150 psi) at the 211-m (691-ft) level in the Tamarisk member.

Four earth pressure cells were installed in the key section of the Salt Handling Shaft during concrete emplacement at the 262-m (860-ft) level. These instruments measure the normal stress between the concrete key and the Salado Formation as the creep effects load on the key structure. Three of the four earth pressure cells continue to provide data, although all three are reporting negative pressures. The contact pressures recorded by the instruments for this reporting period ranged from -15 to -195 KPa (-2 to -28 psi).

Sixteen spot welded and twenty-four embedment strain gages were installed on and in the shaft key concrete at both the 261-m (856.3-ft) level and at the 262.9-m (862.4-ft) level. The two

Salt Handling Shaft



NOTES

1. Radial Convergence Points at each level consist of four points.
2. The term "level" is an approximate depth from the top of the shaft bunton at elevation 1039 m (3409 ft) above mean sea level.
3. Levels are shown in units of meters (m) and feet (ft).
4. Piezometers are oriented at N 30 degrees W and S 30 degrees E.

LEGEND

PE Piezometer

RC Radial Convergence Points

GE Extensometer

Not to Scale

GG853

Figure 3-2
Salt Handling Shaft Instrumentation (Without Shaft Key)

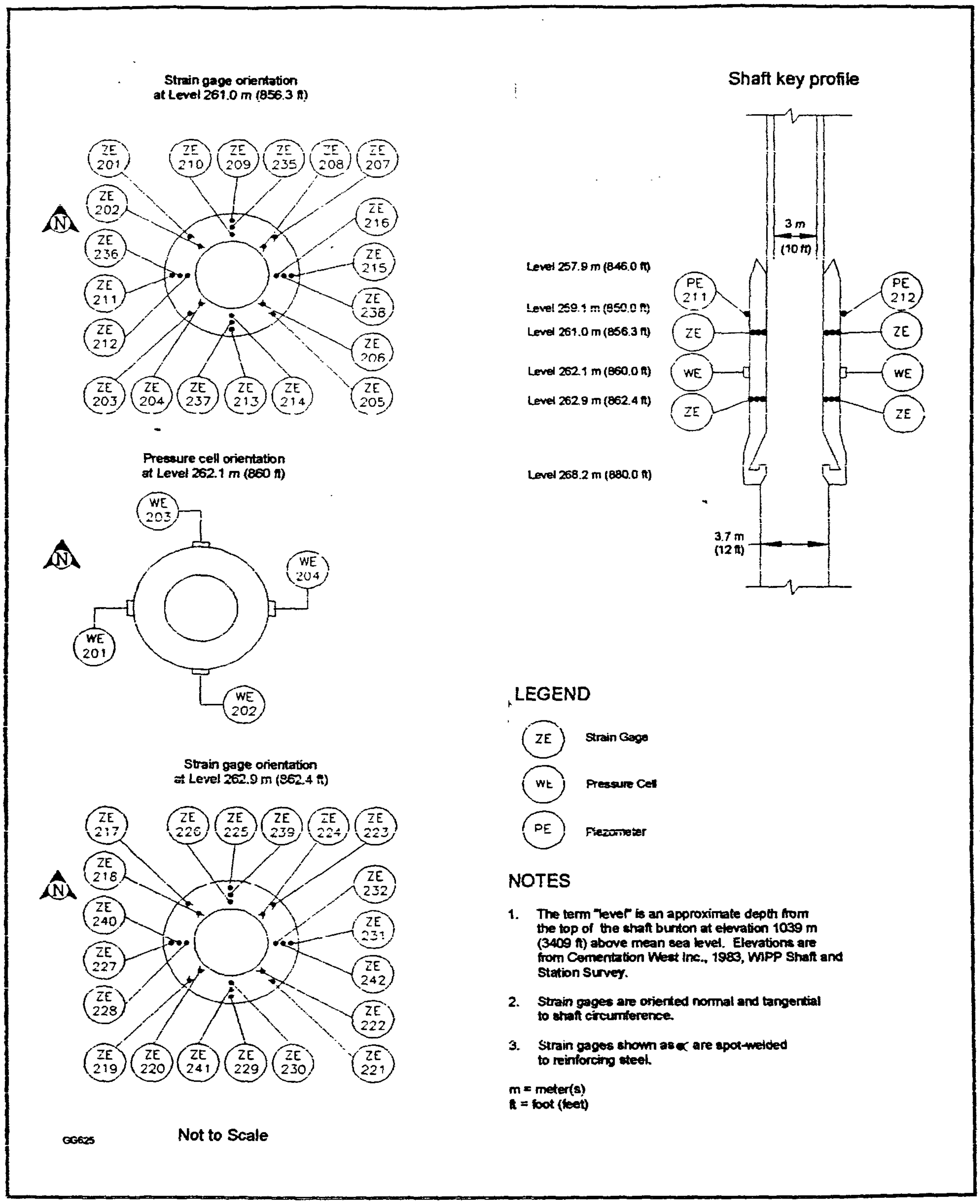


Figure 3-3
Salt Handling Shaft Key Instrumentation

functioning spot-welded strain gages located at the 261-m (856.3-ft) level reported strains of 625 and 717 microstrain. The strains reported for this reporting period from the 12 embedment strain gages located at the 261-m (856.3-ft) level ranged from -672 microstrain to 942 microstrain.

The 12 embedment strain gages located at the 262.9-m (862.4-ft) level reported strains ranging from -356 to 773 microstrain. All of the spot-welded strain gages located at the 262.9-m (862.4-ft) level have failed, hence no data are available.

3.2 Waste Shaft

As part of the SPDV Program, a 2-m (6-ft) diameter ventilation shaft, now referred to as the Waste Shaft, was excavated from December 1981 through February 1982. This shaft, in combination with the Salt Handling Shaft, provided a two-shaft underground air circulation system. From October 11, 1983, to June 11, 1984, the shaft was enlarged to a diameter of 6 to 7 m (20 to 23 ft) and lined. stratigraphic mapping (Figure 3-4) was conducted during shaft enlargement from December 9, 1983, to June 5, 1984 (Holt and Powers, 1984).

The Waste Shaft is lined with nonreinforced concrete and has a 6-m (19-ft) inside diameter from the ground surface to the top of the Waste Shaft key at 255 m (837 ft). Liner thickness increases with depth from 25 cm (10 in.) at the surface to 51 cm (20 in.) at the key. The Waste Shaft key is 19 m (63 ft) long and 1.3 m (4.25 ft) thick and is constructed of reinforced concrete. The bottom of the key is 274 m (900 ft) below the surface. The diameter of the shaft is 6 m (20 ft) at the point below the key and increases to 7 m (23 ft) just above the shaft station. The shaft below the key is lined with wire mesh anchored by rockbolts. The diameter of 7 m (23 ft) extends to a depth of approximately 697 m (2,286 ft) with the shaft sump comprising the lower 39 m (128 ft) of that interval.

3.2.1 Shaft Observations

Underground operations personnel conduct weekly visual shaft inspections. These inspections are performed principally to assess the condition of the hoisting and mechanical systems, but also include observation of the shaft walls for water seepage, loose rock, or sloughing. The visual shaft inspections during this reporting period showed the Waste Shaft to be in satisfactory condition and no modifications were necessary.

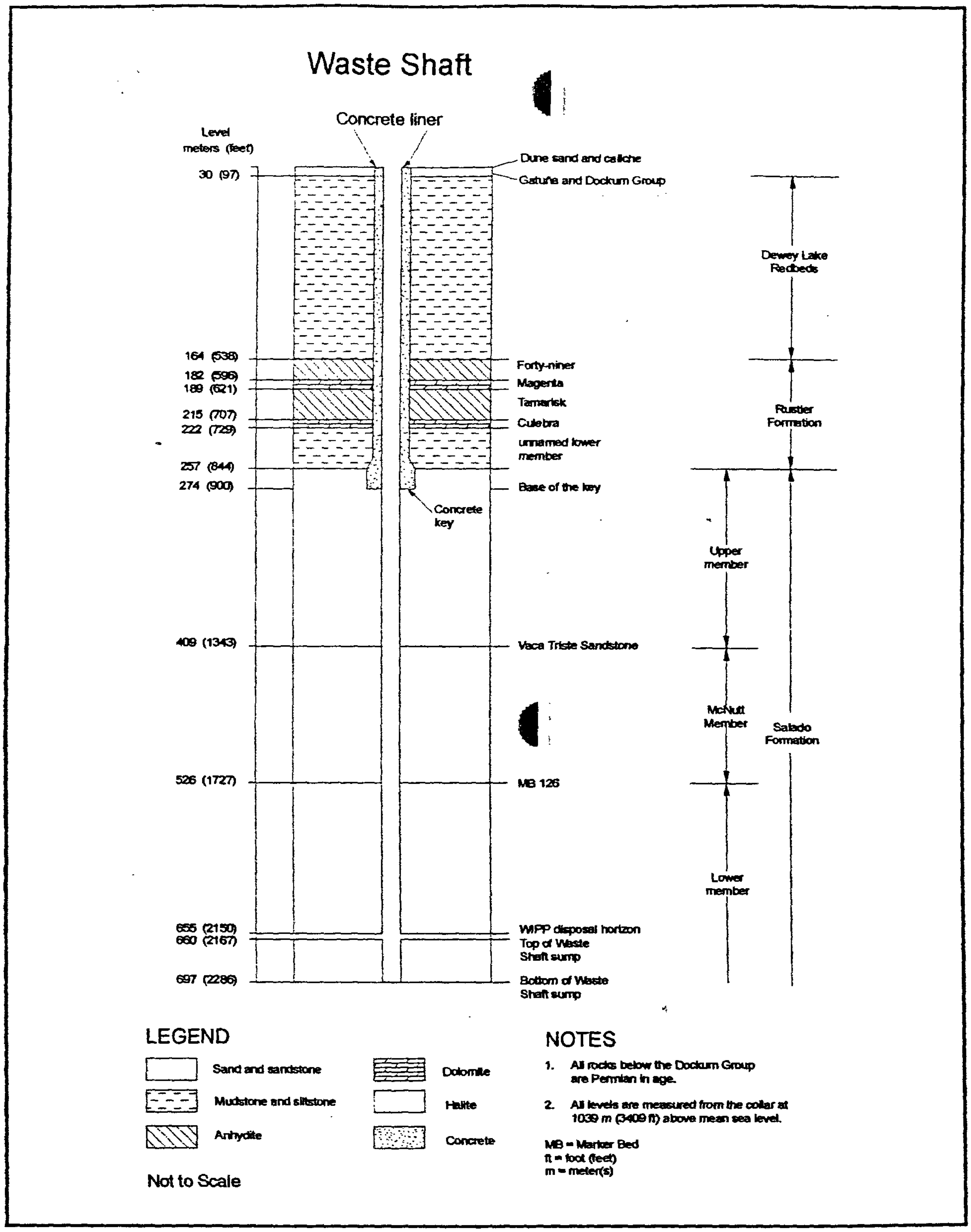


Figure 3-4
Waste Shaft Stratigraphy

3.2.2 Instrumentation

Extensometers, piezometers, earth pressure cells, and radial convergence points were installed in the Waste Shaft between August 27 and September 10, 1984. Figures 3-5 and 3-6 illustrate the instrumentation configurations in the shaft and shaft key.

Nine multiposition borehole extensometers were installed in arrays at 326 m (1,071 ft), 477 m (1,566 ft), and 628 m (2,059 ft) below the surface as shown in Figure 3-5. Each array consists of three extensometers. Currently, eight out of nine extensometers remain functional. Table 3-2 summarizes information regarding collar displacement measurements from these extensometers.

Table 3-2

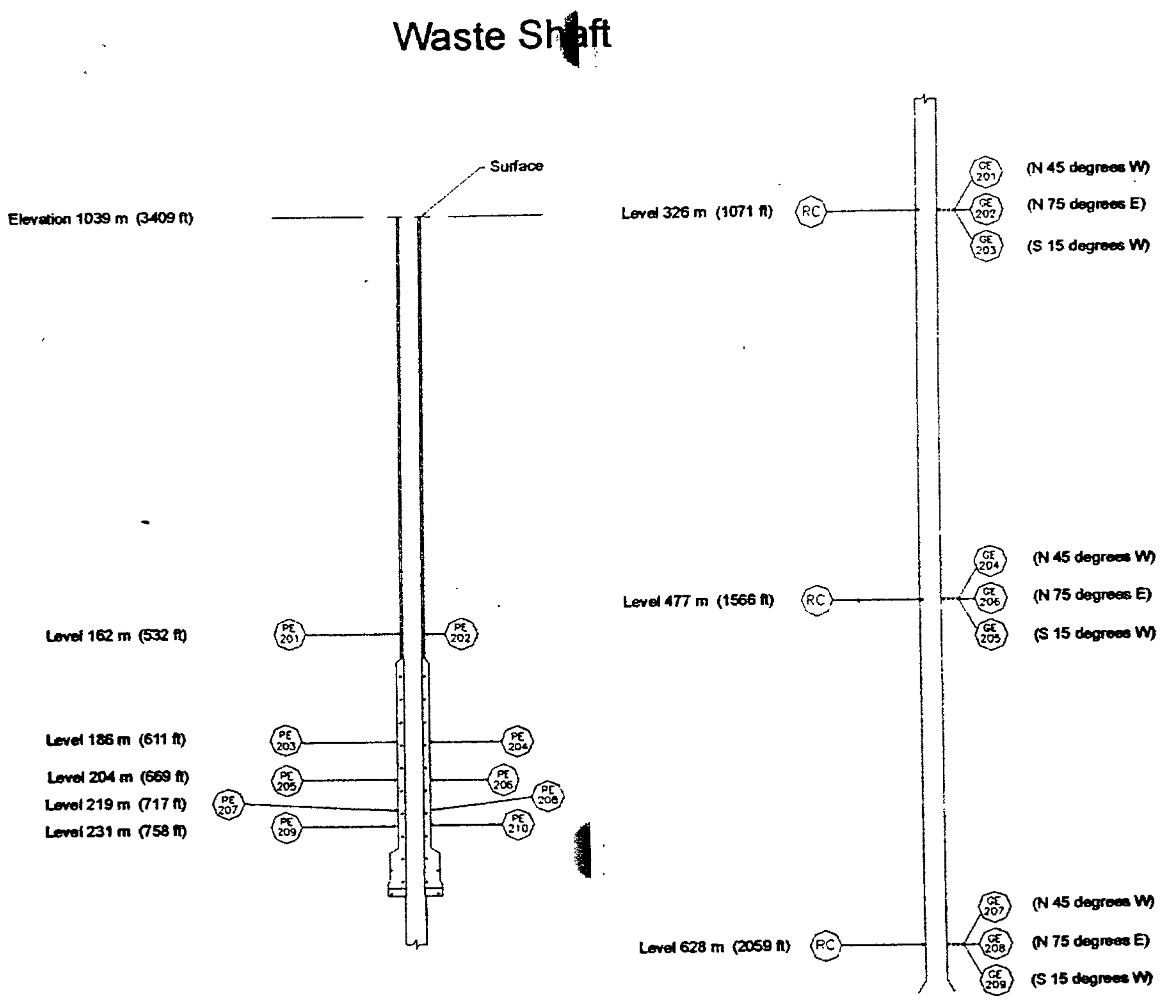
Collar Displacement at Waste Shaft Extensometers

Shaft Level m (ft)	Extensometer Orientation	Collar Displacement cm	in.
326 (1,071)	N45°W	0.57	0.22
	N75°E	Instrument malfunction	
	S15°W	0.42	0.16
477 (1,566)	N45°W	1.58	0.62
	N75°E	1.60	0.63
	S15°W	1.32	0.52
628 (2,059)	N45°W	4.00	1.58
	N75°E	3.77	1.48
	S15°W	4.24	1.67

cm = centimeter(s)
ft = foot (feet)
in. = inch(es)
m = meter(s)

Twelve piezometers were installed in the lined section of the Waste Shaft on September 7 and 8, 1984, to monitor pressure behind the shaft liner and key section in the shaft. Data continue to be received from all 12 piezometers, although 6 of the 12 report a zero or negative fluid pressure. The recorded positive fluid pressures from the remaining 6 piezometers range from less than 225 KPa (33 psi) at the unnamed lower member (231-m [758-ft] depth) up to greater than 1,000 KPa (148 psi) at the level where the shaft intersects the Culebra Dolomite (219-m [719-ft] depth).

Four earth pressure cells were installed in the key section of the Waste Shaft during concrete emplacement between March 23 and April 3, 1984. These instruments measure the normal stress between the concrete key and the Salado Formation as the salt creep loads the key structure. Three of the four earth pressure cells remain in working condition. The contact



NOTES

1. RCs at each level consist of four points.
2. The term "level" is an approximate depth from the shaft collar at elevation 1039 m (3049 ft) above mean sea level.
3. Piezometers are oriented at N 30 degrees W and S 30 degrees E.

ft = foot (feet)
m = meter(s)

Not to Scale

LEGEND

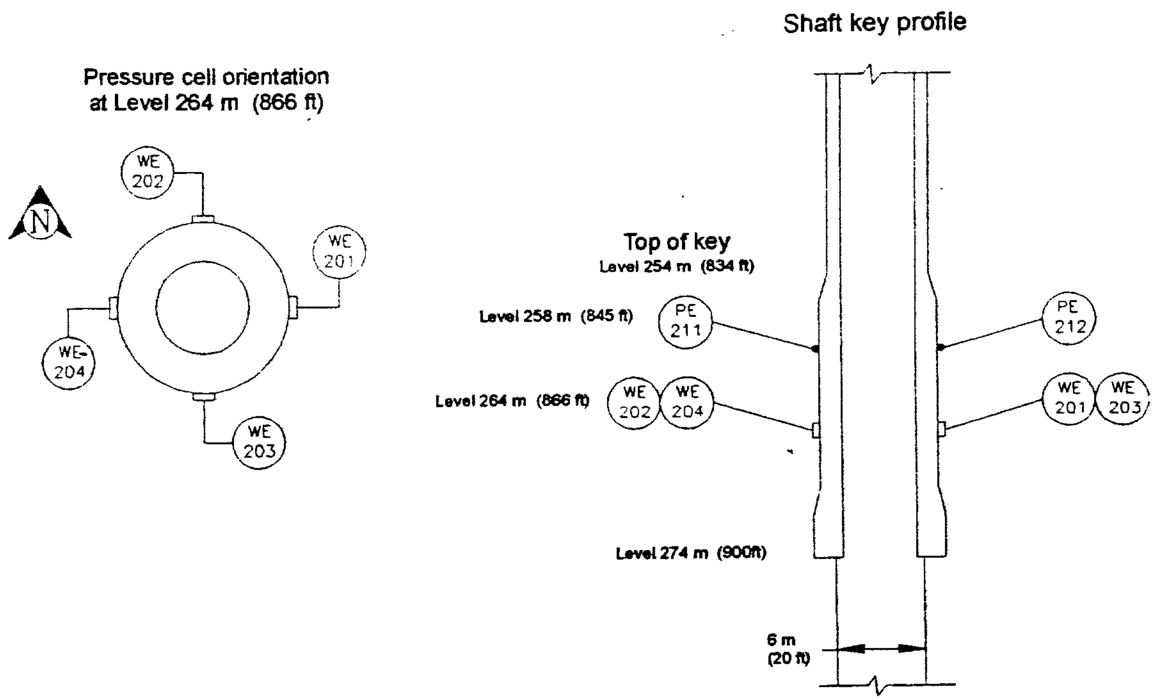
PE Piezometer

RC Convergence Points

GE Extensometer

GG654.2

Figure 3-5
Waste Shaft Instrumentation (Without Shaft Key)



NOTES

1. The term "level" is an approximate depth from the shaft collar at elevation 1039 m (3409 ft) above mean sea level.

2. Pressure cells are located at concrete-rock interface

ft = foot (feet)
m = meter(s)

Not to Scale

LEGEND

WE Pressure Cell

PE Piezometer

Figure 3-6
Waste Shaft Key Instrumentation

pressure recorded by the instruments has remained fairly constant over the past five years. The pressures recorded during this reporting period were between 800 and 900 KPa (116 and 129 psi).

3.3 Exhaust Shaft

The Exhaust Shaft was drilled from September 22, 1983, to November 29, 1984, to establish a route from the underground facility to the surface for exhaust air. Stratigraphic mapping was conducted from July 16, 1984, to January 18, 1985, (DOE, 1986c). Figure 3-7 illustrates the Exhaust Shaft stratigraphy.

The Exhaust Shaft is lined with nonreinforced concrete from the surface to the top of the shaft key at a depth of 257 m (844 ft). The liner thickness increases from 25 to 41 cm (10 to 16 in.) over that interval. The Exhaust Shaft key is 19 m (63 ft) long and 1 m (3.5 ft) thick. The shaft diameter below the key is 5 m (15 ft) and the interval below the key is lined with wire mesh anchored by rockbolts. The shaft terminates at the facility horizon, at a depth of approximately 655 m (2,150 ft). There is no excavated shaft sump.

3.3.1 Shaft Observations

Quarterly remote video inspections of the shaft indicate that the shaft is in satisfactory condition and no modifications were made during this reporting period.

In March 1995 a scheduled inspection revealed a thin stream of water emerging from the liner into the shaft, at a depth of approximately 23 to 24 m (75 to 80 ft) below the shaft collar. A program was initiated to investigate the source and extent of the water. Results from that program are published separately (Intera, 1997; IT, 1997). A catchment basin was installed at the base of the Exhaust Shaft in 1995 to collect the excess fluid. The volume of water removed from the Exhaust Shaft catchment basin during this reporting period typically ranged from 0 to 2,400 liters (0 to 600 gallons) per week.

3.3.2 Instrumentation

The Exhaust Shaft was equipped with geomechanical instrumentation in two stages. Earth pressure cells were installed behind the liner key in November 1984. Piezometers and nine multiposition borehole extensometers were installed during November and December 1985. Figures 3-8 and 3-9 illustrate the instrumentation configuration.

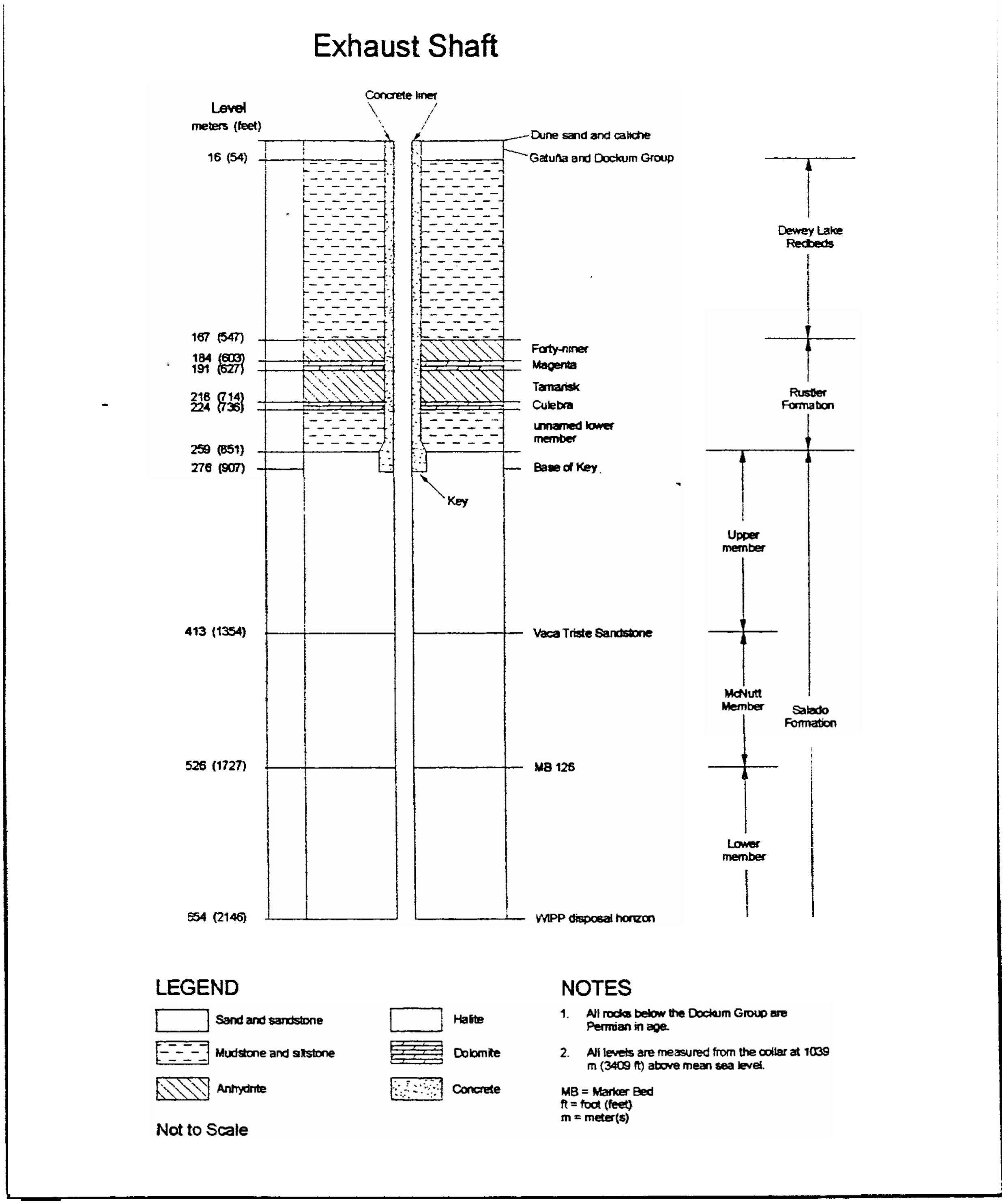


Figure 3-7
Exhaust Shaft Stratigraphy

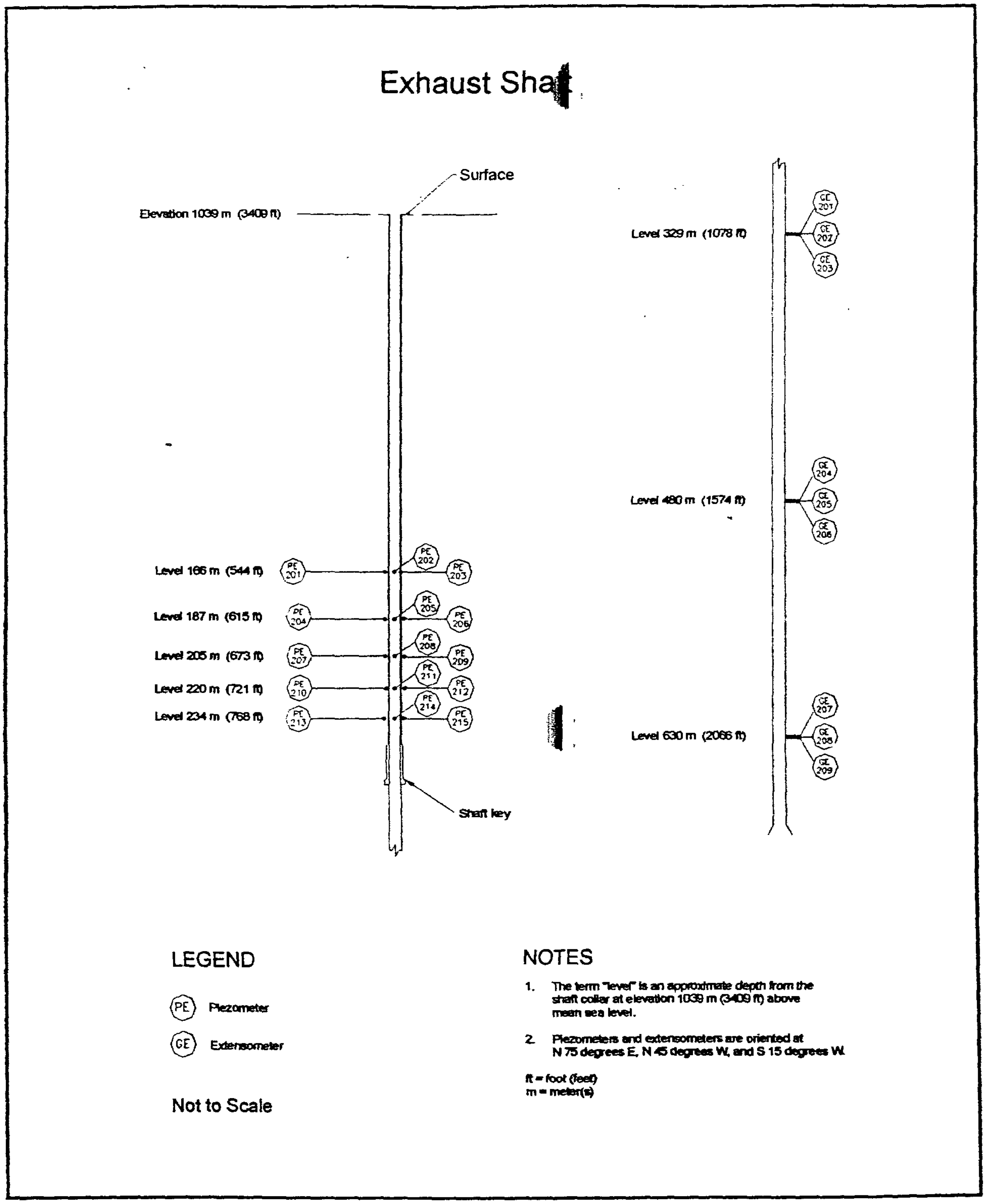
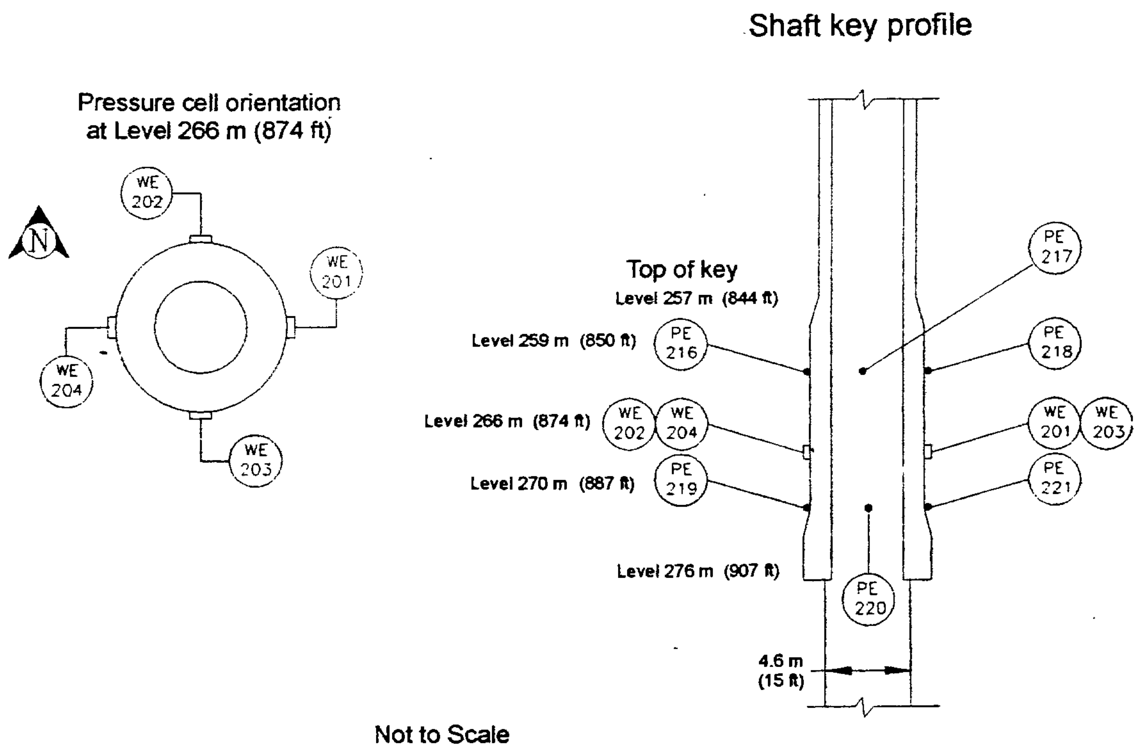


Figure 3-8
Exhaust Shaft Instrumentation (Without Shaft Key)



LEGEND

WE Pressure Cell

PE Piezometer

NOTES

1. The term "level" is an approximate depth from the shaft collar at elevation 1039 m (3049 ft) above mean sea level.
2. Pressure cells are located at concrete-rock interface and oriented at azimuths of 0 degrees, 90 degrees, 180 degrees, and 270 degrees.
3. Piezometers are oriented at N 75 degrees E, N 45 degrees W, and S 15 degrees W.

ft = foot (feet)
m = meter(s)

Figure 3-9
Exhaust Shaft Key Instrumentation

Fourteen of the twenty-one piezometers installed remain in working condition. The fluid pressure readings from the working piezometers at the end of the reporting period range from 0 KPa at the 166-m (544-ft) level to almost 1,000 KPa at the 220-m (721-ft) level.

No data could be collected from the extensometers for this reporting period. The extensometers have failed and have not provided data since April 1996.

Two earth pressure cells that had been functioning properly during the last reporting period failed during this reporting period. Currently there are no working earth pressure cells in the Exhaust Shaft.

Limited access and the absence of any shaft conveyance preclude replacing the malfunctioning instruments in the Exhaust Shaft.

3.4 Air Intake Shaft

The Air Intake Shaft was drilled from December 4, 1987, to August 31, 1988, to establish a dedicated route for surface air to enter the repository. Stratigraphic mapping was conducted from September 14, 1988, to November 14, 1989 (Holt and Powers, 1990). Figure 3-10 illustrates the Air Intake Shaft stratigraphy.

The Air Intake Shaft is lined with nonreinforced concrete from the surface to a depth of 275 m (903 ft) (the bottom of the shaft key). The Air Intake Shaft key is 25 m (81 ft) long with an inside diameter of 5 m (16 ft). The diameter below the shaft key is 6 m (20 ft), and the shaft is unlined below the key to the facility horizon at a depth of 655 m (2,150 ft). The Air Intake Shaft has no sump.

3.4.1 Shaft Performance

Weekly visual inspections were performed on the Air Intake Shaft during this reporting period and the shaft was found to be in satisfactory condition. Some ground control activities were performed in the Air Intake Shaft during this reporting period. Table 3-3 summarizes these modifications.

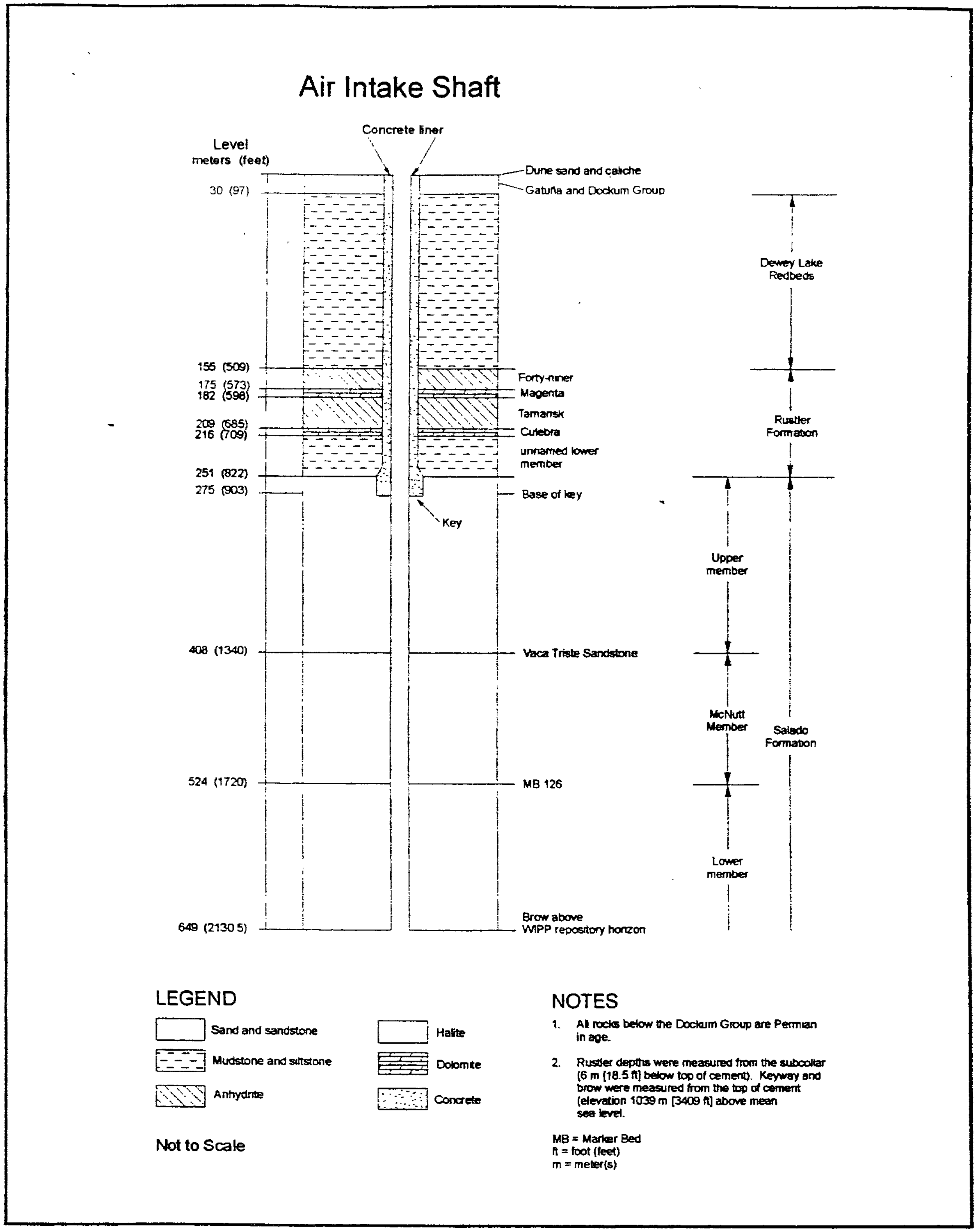


Figure 3-10
Air Intake Shaft Stratigraphy

Table 3-3
Summary of Ground Control Activities in the Air Intake Shaft
July 1, 1997 through June 30, 1998

Date Completed	Work Performed
October 1997	Completed scaling of shaft walls
March 1998	Completed rockbolting and installation of wire mesh at a mud seam at 1180 feet below ground surface

3.4.2 Instrumentation

Sandia National Laboratories/New Mexico (SNL/NM) installed geomechanical instruments in the shaft in 1988. SNL/NM maintains responsibility for the operation of all of the instruments located in the Air Intake Shaft as well as for data acquisition and instrument maintenance. SNL/NM has continuously monitored these instruments since their installation. Data from these instruments are available from SNL/NM by request. Some data from these instruments have been reported by SNL/NM in two separate documents (Munson, et. al., 1995; Holcomb, 1997).

4.0 Performance of Shaft Stations

This chapter describes the geomechanical performance of the enlarged working areas (called shaft stations) around the intersections of the Salt Handling Shaft and the Waste Shaft with the underground facility. The Exhaust Shaft does not have an enlarged shaft station. Because there are no geotechnical instruments monitored in the Air Intake Shaft Station, discussion of the Air Intake Shaft Station in this chapter is limited to reporting ground control activities and modifications. Data from two extensometers located in the access drift in the vicinity of the Air Intake Shaft Station are presented in Chapter 5.0 of this report.

4.1 Salt Handling Shaft Station

The Salt Handling Shaft Station was excavated between May 2 and June 3, 1982, by drilling and blasting. In 1987 the station was enlarged, removing the roof beam up to Anhydrite "b" between S90 and N20 using a mechanical scaler. In 1995 the remaining roof beam at the north end of the station was also removed up to Anhydrite "b." The station area south of the shaft is 27.5 m (90 ft) long and 10 to 12 m (32 to 38 ft) wide. The height of the station south of the shaft is 5.5 m (18 ft). The station dimensions north of the shaft are approximately 9 m (30 ft) long, 10 to 11 m (32 to 35 ft) wide, and 5.5 m (18 ft) high. The shaft extends approximately 43 m (140 ft) below the facility horizon in order to accommodate the skip loading equipment and to act as a sump. Figure 4-1 shows a generalized cross section of the station.

4.1.1 Modifications to Excavation and Ground Control Activities

No modifications were made in the Salt Handling Shaft Station during this reporting period. Table 4-1 summarizes the ground control activities performed during this reporting period.

Table 4-1
Summary of Ground Control Activities in the Salt Handling Shaft Station
July 1, 1997 through June 30, 1998

Date Completed	Work Performed
January 1998	Completed scaling activities in the shaft sump
February 1998	Completed scaling of the brow above the Shaft Station to relieve pressure on steel sets and guides

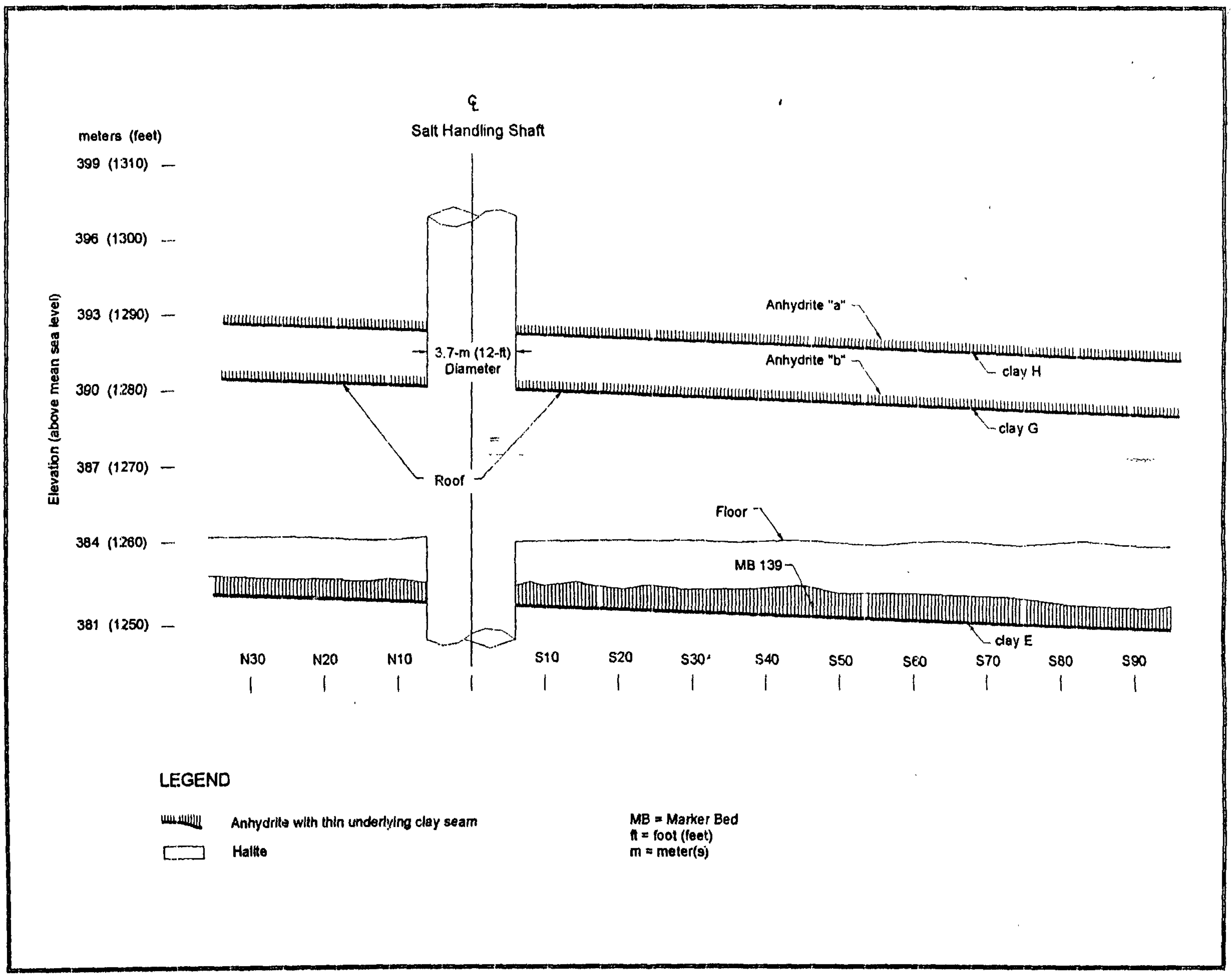


Figure 4-1
Salt Handling Shaft Station Stratigraphy

4.1.2 Instrumentation

Geomechanical instrumentation was installed in the Salt Handling Shaft Station between June 1982 and February 1983, with subsequent reinstallation of extensometers and convergence points as necessary. Figure 4-2 shows the instrument locations in the Salt Handling Shaft Station before the roof beam was removed in 1987. Affected instruments were either removed, or readings were suspended prior to mining the roof beam. Figure 4-3 shows the instrument locations after the roof beam was taken down.

There are three extensometers located in the Salt Handling Shaft Station. Because of instrument malfunctions of all three extensometers, there are no extensometer data for the Salt Handling Shaft Station for this reporting period. Five vertical convergence point arrays and one horizontal convergence chord, located at E0-N39, are currently monitored. Table 4-2 summarizes the vertical closure rates in the Salt Handling Shaft Station from the 1995 through 1998. Salt Handling Shaft Station vertical closure rates have remained consistent for the last four years.

Table 4-2
Vertical Closure Rates in the Salt Handling Shaft Station

Location		June 1995 Closure Rate cm/yr (in./yr)	June 1996 Closure Rate cm/yr (in./yr)	June 1997 Closure Rate cm/yr (in./yr)	June 1998 Closure Rate cm/yr (in./yr)
E0-N39	Drift centerline	5.12 (2.01)[a]	5.01 (1.97)[a]	4.76 (1.87)	4.90 (1.93)
E0-W12	Along west rib	1.97 (0.78)	2.09 (0.82)	1.87 (0.73)	2.02 (0.79)
E0-S18	Along east rib	4.21 (1.66)	4.19 (1.65)	4.37 (1.72)	3.59 (1.41)
E0-S18	Along west rib	2.65 (1.04)	2.65 (1.04)	2.42 (0.95)	2.64 (1.04)
E0-S18	Drift centerline	3.78 (1.49)	3.82 (1.50)	3.58 (1.41)	3.78 (1.49)
E0-S30	Drift centerline	4.13 (1.62)	4.06 (1.60)	3.83 (1.51)	3.92 (1.54)
E0-S65	Drift centerline	3.18 (1.25)	3.08 (1.21)	2.96 (1.16)	3.01 (1.19)

[a] Closure rate based on data that are less than one complete reporting year.
cm/yr = centimeter(s) per year.
in./yr = inch(es) per year.

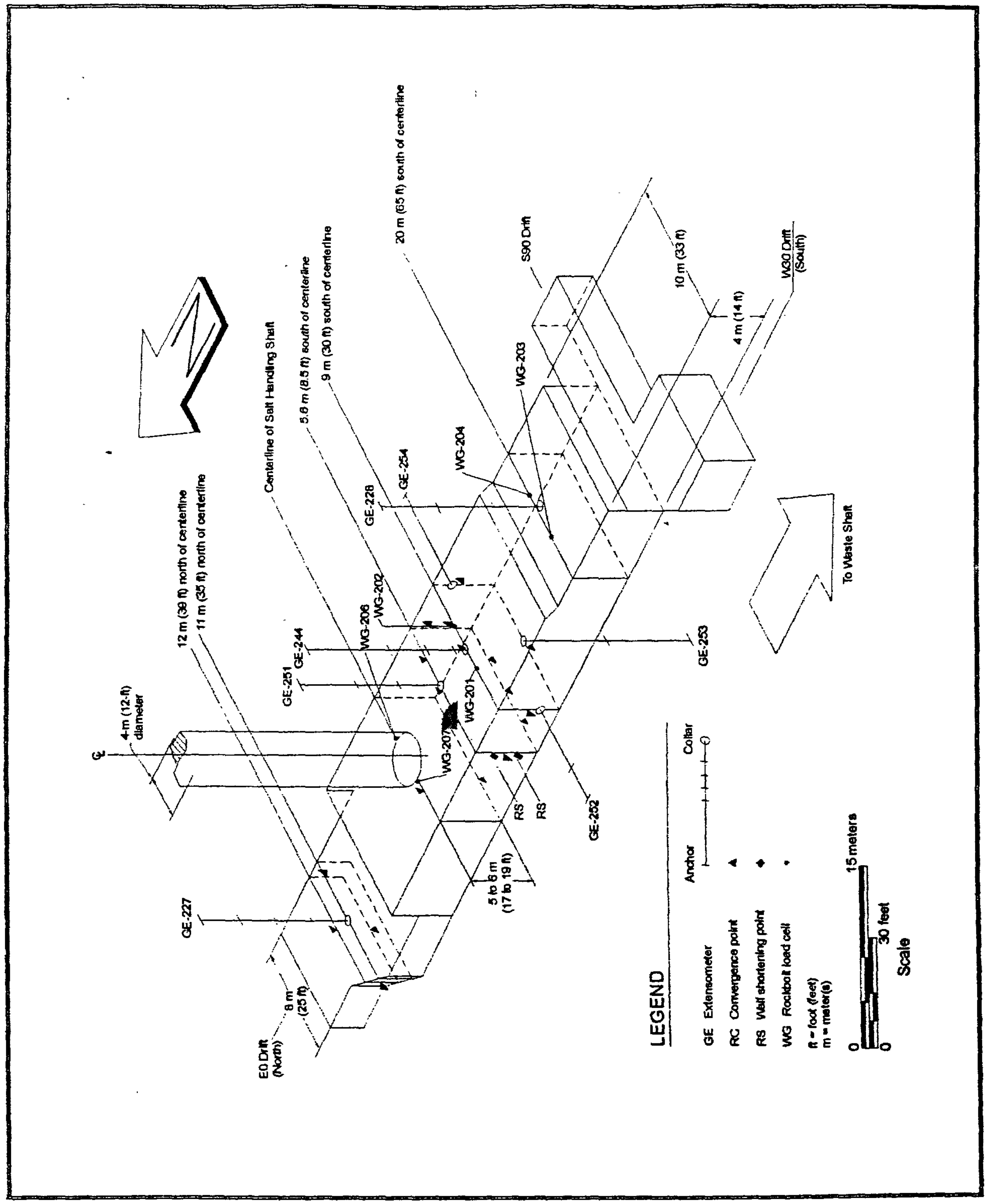


Figure 4-2

Salt Handling Shaft Station Instrumentation Before Roof Beam Excavation

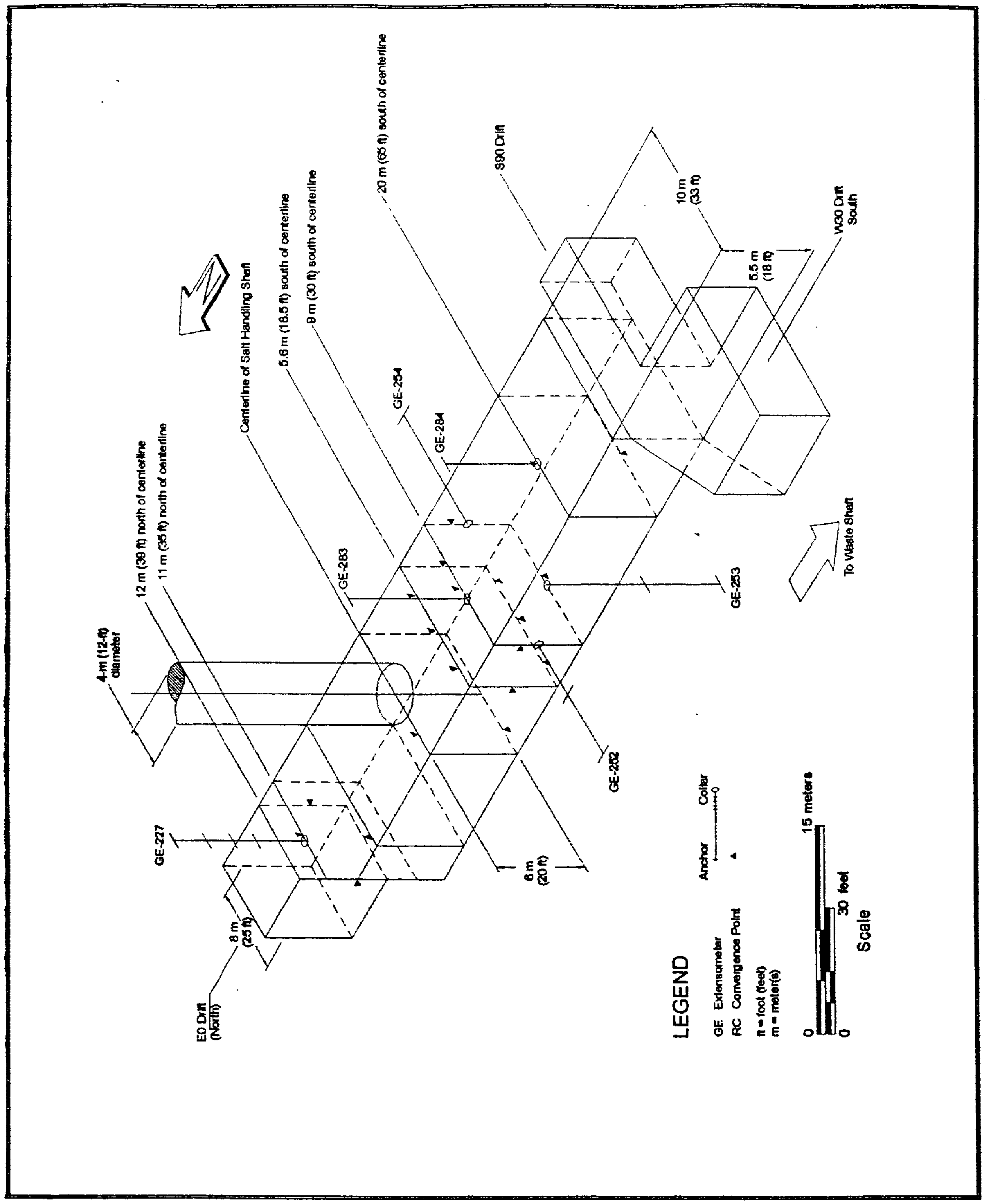


Figure 4-3

Salt Handling Shaft Station Instrumentation After Roof Beam Excavation

4.2 Waste Shaft Station

The Waste Shaft Station was initially excavated with a continuous miner as a ventilation connection to a 2-m (6-ft) diameter exhaust shaft in November 1982. In 1984, the station was enlarged to a height of 4.5 to 6 m (15 to 20 ft) and a width of 6 to 9 m (20 to 30 ft). The station is approximately 46 m (150 ft) long. In 1988 the station walls were trimmed and concrete was placed on the floor. In February 1991 a portion of the concrete slab approximately 16 m (53 ft) long, 7 m (23 ft) wide, and 50 cm (18 in.) thick was removed. During the 1994–1995 reporting period approximately 9 m (30 ft) of the remaining portion of the concrete slab was removed. Figure 4-4 shows a cross section of the Waste Shaft Station.

4.2.1 Modifications to Excavation and Ground Control Activities

No modifications or ground control activities were performed in the Waste Shaft Station during this reporting period.

4.2.2 Instrumentation

Instruments were initially installed in the Waste Shaft Station between November 12 and December 2, 1982. Figure 4-5 illustrates the instrument locations in the Waste Shaft Station before it was enlarged in 1988. Figure 4-6 illustrates the locations after enlargement. Currently there are three working extensometers in the roof of the Waste Shaft Station (located at W30, E35, and E140). In addition, convergence points are monitored at E30 (horizontal convergence points only), E90, and E140.

Table 4-3 summarizes the history of the roof extensometers in the Waste Shaft Station. Of the three functioning extensometers, 51X-GE-00277 at E35 has had the largest amount of displacement across the deepest rod (at a depth of 15.2 m [50 ft]) with a total displacement of 19.05 cm (7.50 in.), followed by 51X-GE-00279 at E140 with a displacement of 16.90 cm (6.65 in.) across the deepest rod (at a depth of 15.2 m [50 ft]), and lastly, 51X-GE-00268 at W30 with a displacement of 15.71 cm (6.19 in.) (at a depth of 15.2 m [50 ft]). The extensometers remain in good working condition and the data indicate a steady displacement rate.

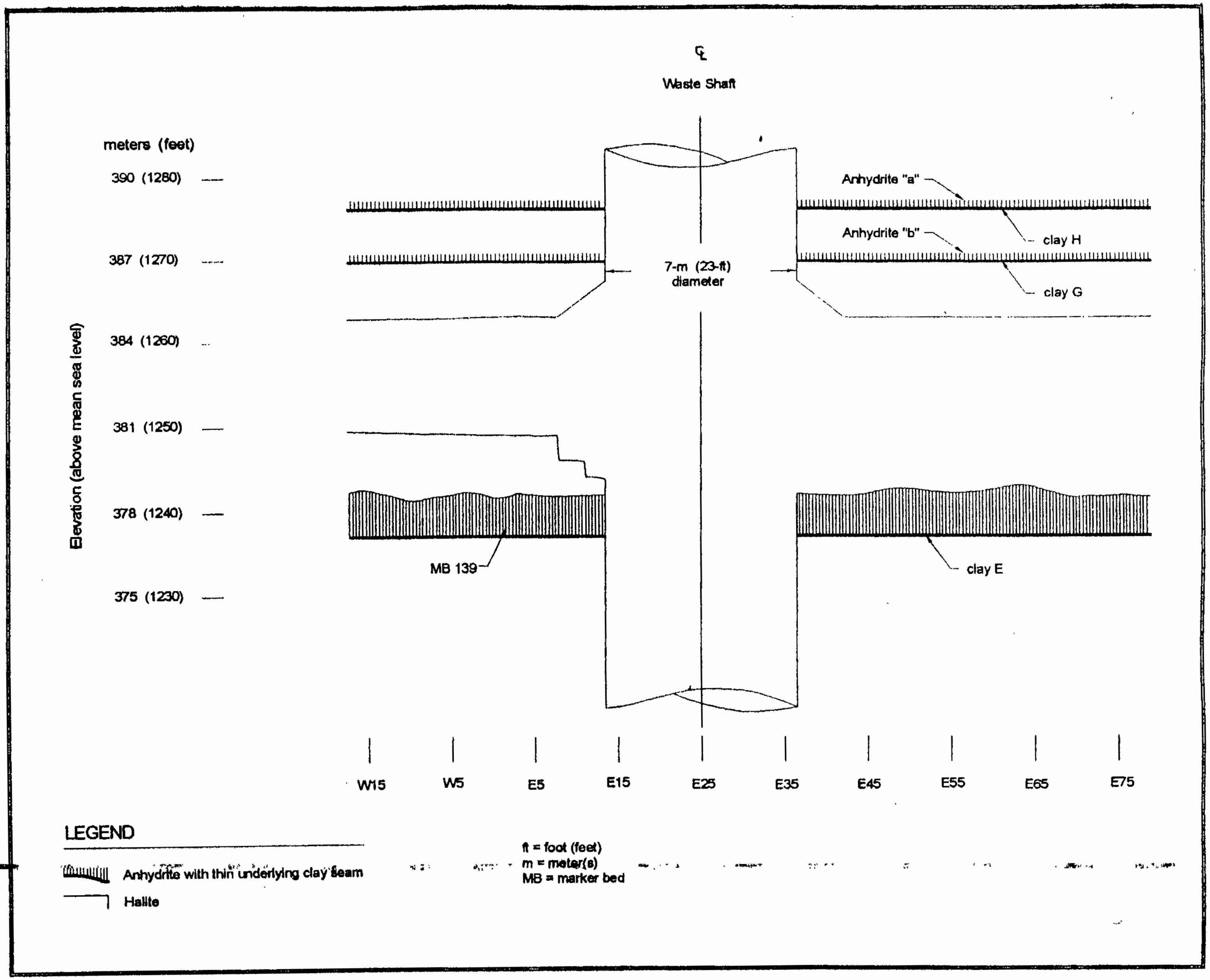


Figure 4-4
Waste Shaft Station Stratigraphy

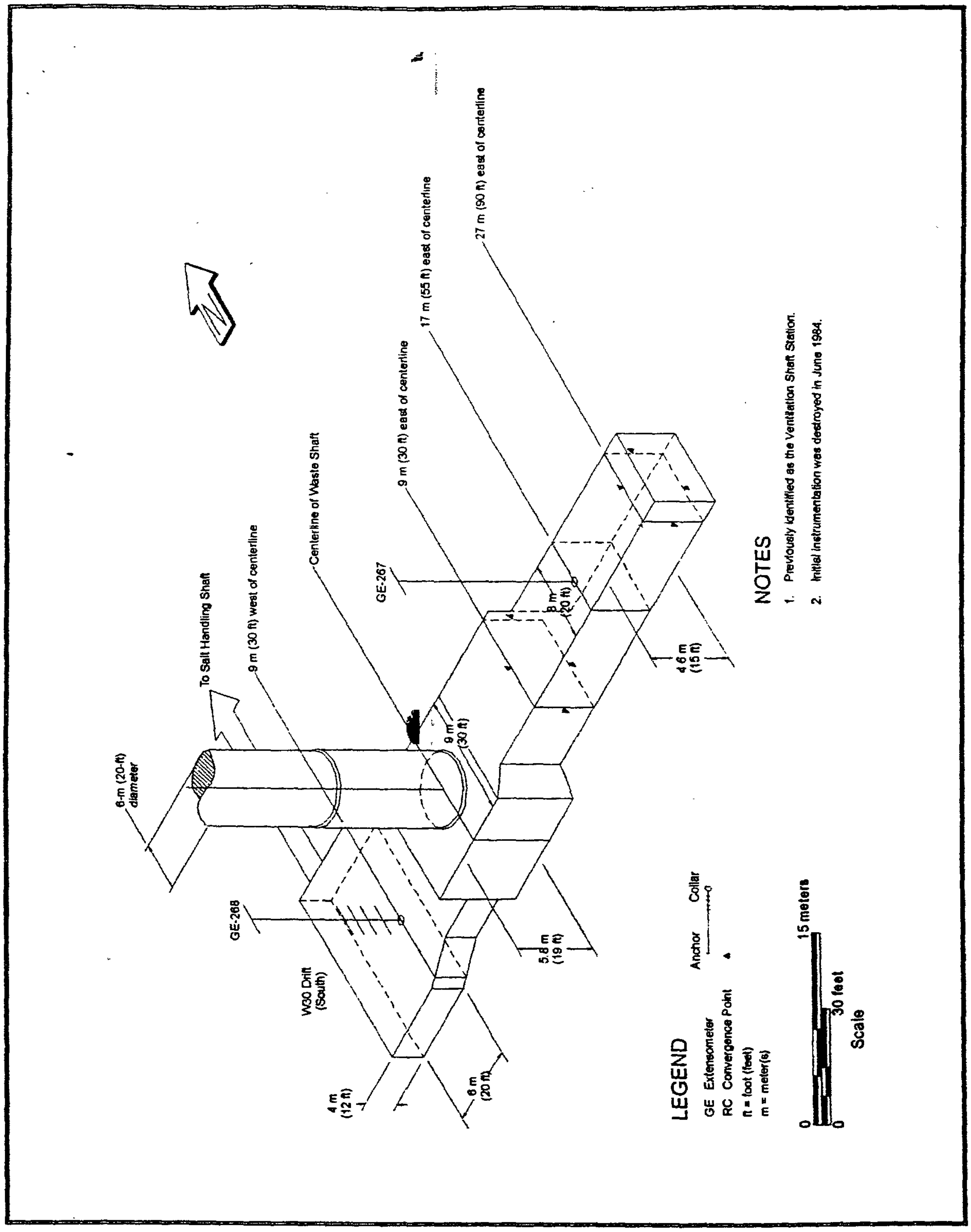


Figure 4-5
Waste Shaft Station Instrumentation Before Wall Trimming

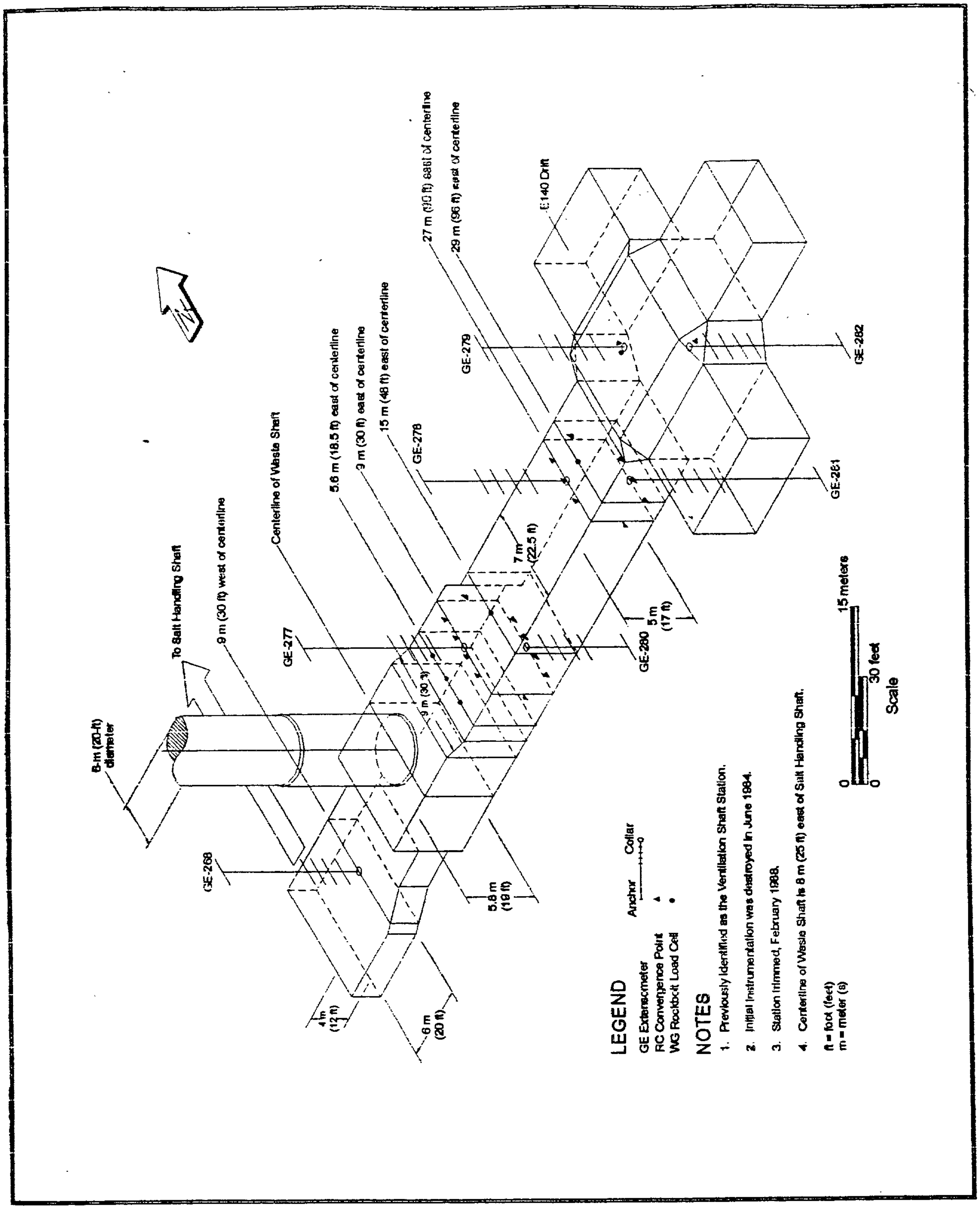


Figure 4-6

Waste Shaft Station Instrumentation After Wall Trimming

Table 4-3
Historical Summary of Roof Extensometers in Waste Shaft Station

Instrument	Date Installed	Last Date Read	Life of Instrument days	Total Displacement of Deepest Rod cm (in.)	Location
Active					
51X-GE-00268	10/24/84	6/1/98	4968	15.71 (6.19)	S400-W30
51X-GE-00277	11/29/88	6/24/98	3494	19.05 (7.50)	S400-E35
51X-GE-00279	11/29/88	6/24/98	3494	16.90 (6.65)	S400-E140
Inactive					
51X-GE-00231	11/13/82	9/12/83	303	3.21 (1.26)	2 m east of shaft centerline
51X-GE-00245	11/18/82	1/14/84	422	3.57 (1.40)	5 m west of shaft centerline
51X-GE-00256	9/1/83	11/25/85	816	6.38 (2.51)	E140-S400 intersection
51X-GE-00257	9/12/83	11/25/85	805	6.57 (2.59)	E140-S400 intersection
51X-GE-00267	4/9/85	2/04/88	1031	5.40 (2.13)	S400-E55
51X-GE-00278	11/29/88	4/28/89	150	0.55 (0.22)	S400-E90

cm = centimeter(s)
in = inch(es)
m = meter(s)

The largest amount of total vertical convergence (as measured by a convergence point array) for this reporting period is located at E90, with a total convergence of 54.20 cm (21.34 in.) over a period of 10.3 years, followed by the E140 intersection. Table 4-4 summarizes the vertical closure rates for the 1995 through 1998 reporting periods. As shown, the data indicate a relatively constant rate of closure over the past several years.

4.3 Air Intake Shaft Station

The Air Intake Shaft Station was excavated in late 1987 and early 1988 using a continuous miner. The Air Intake Shaft is not typically used to transport personnel or materials between the surface and the underground, but does have a work platform that can be raised and lowered in the shaft to perform routine ground control operations. There is minimal operational activity at the Air Intake Shaft Station.

Table 4-4

Vertical Closure Rates in the Waste Shaft Station

Location		1995 Closure Rate cm/yr (in./yr)	1996 Closure Rate cm/yr (in./yr)	1997 Closure Rate cm/yr (in./yr)	1998 Closure Rate cm/yr (in./yr)
S400-E90	Along North Rib	3.35 (1.32)	3.26 (1.28)	3.40 (1.34)	3.50 (1.38)
S400-E90	Drift Centerline	5.00 (1.97)	4.77 (1.88)	4.73 (1.86)	4.66 (1.83)
S400-E90	Along South Rib	4.82 (1.90)	4.51 (1.77)	4.23 (1.66)	4.29 (1.69)
S400-E140	Intersection	4.95 (1.95)	4.73 (1.86)	4.54 (1.79)	4.62 (1.82)

cm/yr = centimeter(s) per year.
in./yr = inch(es) per year.

4.3.1 Modifications to Excavation and Ground Control Activities

No modifications were made in the Air Intake Shaft Station during this reporting period. Table 4-5 summarizes the ground control activities performed during this reporting period.

Table 4-5

Summary of Ground Control Activities in the Air Intake Shaft Station

July 1, 1997 through June 30, 1998

Date Completed	Work Performed
October 1997	Completed scaling of brow and ribs and rebolting of the wire mesh
October 1997	Completed remedial spot bolting of the east rib and station back

4.3.2 Instrumentation

Instrumentation located near the Air Intake Shaft Station is presented in Chapter 5.0 as part of the discussion on the performance of the access drifts.

5.0 Performance of Access Drifts

This chapter describes the geomechanical performance of the central underground access drifts. The Northern Experimental Area and the Waste Disposal Area are discussed later in Chapters 6.0 and 7.0, respectively. There are four major north-south drifts in the WIPP underground, intersected by shorter east-west drifts. These drift dimensions range from 2.4 m (8 ft) to 6.1 m (20 ft) in height and from 4.3 m (14 ft) to 9.8 m (35 ft) in width.

5.1 Modifications to Excavation and Ground Control Activities

No major modifications to the access drifts were performed during this reporting period. Trimming, scaling, and floor milling activities were performed as necessary in several access drifts. Table 5-1 summarizes these activities. Table 5-1 also summarizes ground control activities performed throughout the WIPP underground (e.g. rockbolting and installing wire mesh).

5.2 Entry to South End of E140 Drift

The E140 drift south of S2180 was entered in March 1998 to assess ground conditions. This area of E140 drift has been barricaded for several years. During entry the back and ribs were scaled and sounded, hydraulic roof jacks were placed in "drummy"[2] areas, and spot rockbolting was performed. After completing the assessment of the southern portion of the E140 drift, the drift was rebarricaded south of S2180.

5.3 Instrumentation

Instrumentation installed during this reporting period includes new borehole extensometers, convergence point arrays, and wire convergence meters. This section discusses instrumentation details and locations for each instrumentation type.

5.3.1 Borehole Extensometers

During this reporting period borehole extensometers were installed in the roof of the E140 drift between S1000 and S1950. Many of these extensometers were installed to replace extensometers that had been removed when the roof beam of E140 was excavated to clay G during the previous reporting period. Table 5-2 lists the new extensometers installed during this reporting period, and Figure 5-1 shows the location of all of the geotechnical instruments within

[2] Areas of the back or ribs that give off a hollow or drummy sound when tapped with a steel bar ("sounding"), indicating a possible separation in the rock behind the face.

Table 5-1

Summary of Modifications and Ground Control Activities in the Access Drifts July 1, 1997 through June 30, 1998

Date Completed	Work Performed
	Trimming and Milling Activities
September 1997	Trimming and scaling of the back and ribs in W30 drift between S1300 and S2180
September 1997	Trimming and scaling of S90 drift between W170 and W620
December 1997	Trimming and scaling of E140 drift between S1000 to S1600
January 1998	Trimming and scaling of S400 drift between E300 and the Exhaust Shaft
March 1998	Floor milling of E300 drift between S90 and S350
April 1998	Trimming and scaling of W170 drift between N150 and S90
June 1998	Floor milling of E140 drift between N460 and S1950
	Ground Control Activities
August 1997	Installation of 1180 1.2-m (4-ft) rockbolts, 945 m (3100 ft) of 4-m (13-ft) wire mesh, and 945 m (3100 ft) of 2.5-m (8-ft) wire mesh in E300 drift between S400 and S1600
August 1997	Installation of 27 1.2-m (4-ft) rockbolts and 6.7 m (22 ft) of 2.5-m (8-ft) wire mesh in west brow of E140/S1950 drifts intersection
August 1997	Installation of 50 1.2-m (4-ft) rockbolts and 46 m (150 ft) of 2.5-m (8-ft) wire mesh in E140 drift between S90 and S130
August 1997	Installation of 40 1.2-m (4-ft) rockbolts in W30 drift between S120 and S200
August 1997	Installation of 78 1.2-m (4-ft) rockbolts and 76 m (250 ft) of 2.5-m (8-ft) wire mesh in W170 drift between S1600 and S1950
September 1997	Installation of 37 1.2-m (4-ft) rockbolts, 15 m (50 ft) of 2.5-m (8-ft) wire mesh, and 15 m (50 ft) of 1.2-m (4-ft) wire mesh in E140 drift south of N460
September 1997	Installation of supplemental ground support system consisting of 34 4-m (13.5-ft) threaded bars in office portion of E300 Maintenance Shop
September 1997	Installation of 15 1.2-m (4-ft) rockbolts and 17 m (55 ft) of 2.5-m (8-ft) wire mesh in W170 drift at E100
October 1997	Installation of 100 1.2-m (4-ft) rockbolts, 46 m (150 ft) of 2.5-m (8-ft) wire mesh, and 46 m (150 ft) of 1.2-m (4-ft) wire mesh in E140 drift south of N460
November 1997	Installation of 210 3.7-m (12-ft) rockbolts and 365 4-m (13-ft) rockbolts in the E300 Maintenance Shop
January 1998	Installation of 55 1.2-m (4-ft) rockbolts and 35 m (115 ft) of 2.5-m (8-ft) wire mesh in E140 drift between S200 and S250
January 1998	Installation of 957 1.2-m (4-ft) rockbolts and 576 m (1890 ft) of 2.5-m (8-ft) wire mesh in W30 drift between S1300 and S1950
May 1998	Installation of 100 1.2-m (4-ft) rockbolts and 183 m (600 ft) of 2.5-m (8-ft) wire mesh in W170 drift between S1300 and S1600
June 1998	Installation of 40 1.2-m (4-ft) rockbolts, 8 m (25 ft) of 2.5-m (8-ft) wire mesh, and 8 m (25 ft) of 1.2-m (4-ft) wire mesh at the W170/S1600 drift intersection

ft = foot (feet)

m = meter(s)

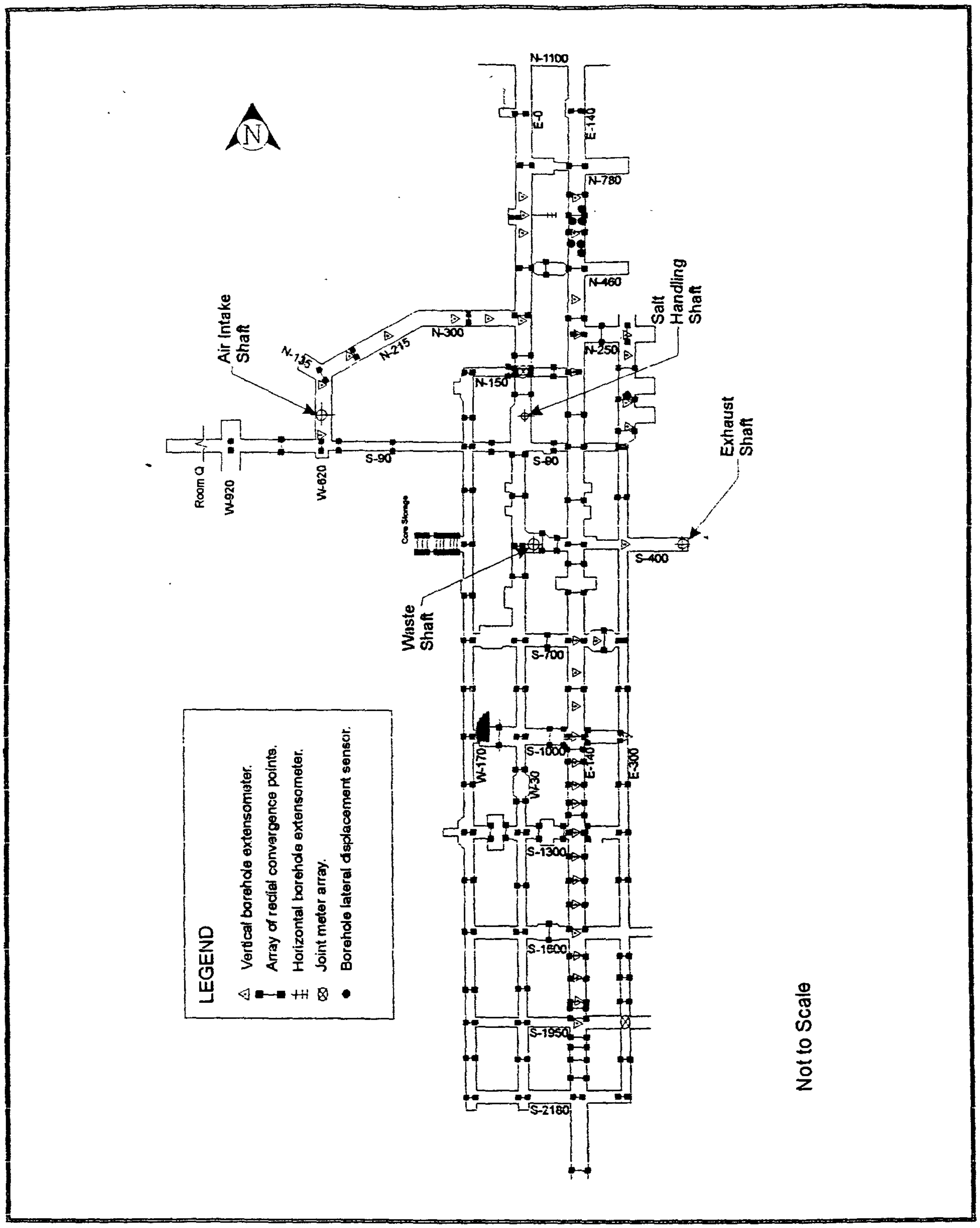


Figure 5-1

Location of Geotechnical Instruments in the Access Drifts

Table 5-2

New Extensometers Installed in the Access Drifts

July 1, 1997 through June 30, 1998

Field Tag	Location	Date Installed
41X-GE-00101	E140 Drift at S1775	3/11/98
41X-GE-00102	E140 Drift at S1450	3/9/98
41X-GE-00103	E140 Drift at S1150	3/2/98
51X-GE-00333	E140 Drift at S1075	4/1/98
51X-GE-00334	E140 Drift at S1225	4/1/98
51X-GE-00335	E140 Drift at S1300 intersection	4/1/98
51X-GE-00336	E140 Drift at S1375	4/1/98
51X-GE-00337	E140 Drift at S1525	4/1/98
51X-GE-00338	E140 Drift at S1600 intersection	4/1/98
51X-GE-00339	E140 Drift at S1685	3/27/98
51X-GE-00340	E140 Drift at S1865	3/27/98

the WIPP access drifts. All operating underground extensometers continue to be monitored. Remotely and manually read extensometers are typically read monthly, although some instruments may be read more frequently.

5.3.2 Convergence Points

Convergence points were reinstalled in various locations throughout the WIPP underground where rib, back, or floor trimming activities had been performed during this and the previous reporting period. Horizontal and vertical convergence point arrays were installed in the E140 drift between N460 and S2180 to replace points that were removed when the floor was milled between N460 and S1950, and when the ribs had been trimmed and scaled between S1000 and S1600. Convergence points within the access drifts are read manually at least every two months, with more frequent monitoring in some areas. Table 5-3 lists the new and replacement convergence points that were installed during this reporting period. Figure 5-1 shows the locations of all of the monitored convergence point arrays in the WIPP access drifts.

During entry into the E140 drift, three wire convergence meters were installed so that roof-to-floor convergence could be monitored remotely. These wire convergence meters are located at S2350, S2431, and S2520.

Table 5-3
New and Replaced Convergence Points Installed in the Access Drifts
July 1, 1997 through June 30, 1998

Instrument Type	N/R	Field Tag	Location	Date Installed
Convergence Points	N	E300-S2065 (A-C, B-D)	E300 Drift at S2065 (All Chords)	7/18/97
Convergence Points	N	E140-S2122 (A-C)	E140 Drift at S2122 (Roof-to-Floor)	7/18/97
Convergence Points	N	E140-S2007 (A-C)	E140 Drift at S2007 (Roof-to-Floor)	7/22/97
Convergence Points	N	E140-S2065 (A-C, B-D)	E140 Drift at S2065 (All Chords)	7/22/97
Convergence Points	N	E300-S1450 (A-C, B-D)	E300 Drift at S1450 (All Chords)	7/29/97
Convergence Points	N	E300-S1862 (A-C, B-D)	E300 Drift at S1862 (All Chords)	7/29/97
Convergence Points	N	E300-S1775 (A-C, B-D)	E300 Drift at S1775 (All Chords)	7/29/97
Convergence Points	N	E300-S1687 (A-C, B-D)	E300 Drift at S1687 (All Chords)	7/29/97
Convergence Points	R	E300-S250-2 (B-D)	E300 Drift at S250 (Rib-to-Rib)	9/23/97
Convergence Points	R	W30-S1775-2 (B-D)	W30 Drift at S1775 (Rib-to-Rib)	9/23/97
Convergence Points	R	W30-S2067-2 (B-D)	W30 Drift at S2067 (Rib-to-Rib)	9/23/97
Convergence Points	R	W30-S1453-2 (B-D)	W30 Drift at S1453 (Rib-to-Rib)	9/23/97
Convergence Points	R	S90-W400-2 (B-D)	S90 Drift at W400 (Rib-to-Rib)	9/30/97
Convergence Points	R	S90-W590-2 (B-D)	S90 Drift at W590 (Rib-to-Rib)	9/30/97
Convergence Points	R	E140-S1917-2 (A-C)	E140 Drift at S1917 (Roof-to-Floor)	1/9/98
Convergence Points	R	E140-S1862-2 (C-G)	E140 Drift at S1862 (Rib-to-Rib)	1/9/98
Convergence Points	R	E140-S1775-2 (D-J, I-E)	E140 Drift at S1775 (Rib-to-Rib)	1/9/98
Convergence Points	R	E140-S1456-2 (D-J, I-E)	E140 Drift at S1456 (Rib-to-Rib)	1/9/98
Convergence Points	R	E140-S1534-2 (C-G)	E140 Drift at S1534 (Rib-to-Rib)	1/9/98
Convergence Points	R	E140-S1150-2 (D-J, I-E)	E140 Drift at S1150 (Rib-to-Rib)	1/13/98
~~Convergence Points~~	~~R~~	~~E140-S1075-2 (C-G)~~	E140 Drift at S1075 (Rib-to-Rib)	1/13/98
Convergence Points	R	E140-S1225-2 (C-G)	E140 Drift at S1225 (Rib-to-Rib)	1/13/98
Convergence Points	R	E140-S90-3 (A-C)	E140 Drift at S90 (Roof-to-Floor)	2/3/98
Convergence Points	R	E140-N5-4 (A-C)	E140 Drift at N5 (Roof-to-Floor)	2/3/98
Convergence Points	R	E300-S250-2 (A-C)	E300 Drift at S250 (Roof-to-Floor)	4/6/98

Table 5-3 (Continued)
New and Replaced Convergence Points Installed in the Access Drifts
July 1, 1997 through June 30, 1998

Instrument Type	N/R	Field Tag	Location	Date Installed
Convergence Points	R	E140-S550-4 (A-C)	E140 Drift at S550 (Roof-to-Floor)	4/7/98
Convergence Points	R	E300-N250-2 (A-C)	E300 Drift at N250 (Roof-to-Floor)	4/8/98
Convergence Points	R	E140-S700-4 (A-D, B-C, E-F)	E140 Drift at S700 (Roof-to-Floor)	4/9/98
Convergence Points	R	E140-N300-2 (A-C)	E140 Drift at N300 (Roof-to-Floor)	4/21/98
Convergence Points	R	W170-S5-2 (B-D)	W170 Drift at S5 (Rib-to-Rib)	4/21/98
Convergence Points	R	E140-S850-7 (A-C)	E140 Drift at S850 (Roof-to-Floor)	4/21/98
Convergence Points	R	E140-S460-4 (A-C)	E140 Drift at S460 (Roof-to-Floor)	6/1/98
Convergence Points	R	S1950-E113-3 (A-C)	S1950 Drift at E113 (Roof-to-Floor)	6/23/98
Convergence Points	R	E140-S1025-2 (A-C)	E140 Drift at S1025 (Roof-to-Floor)	6/23/98
Convergence Points	R	E140-S1075-2 (A-E, B-D, H-F)	E140 Drift at S1075 (Roof-to-Floor)	6/23/98
Convergence Points	R	E140-S1150-2 (A-G, B-F, L-H)	E140 Drift at S1150 (Roof-to-Floor)	6/23/98
Convergence Points	R	E140-S1225-2 (A-E, B-D, H-F)	E140 Drift at S1225 (Roof-to-Floor)	6/23/98
Convergence Points	R	E140-S1300-4 (A-C)	E140 Drift at S1300 (Roof-to-Floor)	6/23/98
Convergence Points	R	E140-S1378-2 (A-E, B-D, H-F)	E140 Drift at S1378 (Roof-to-Floor)	6/23/98
Convergence Points	R	E140-S1456-2 (A-G, B-F, L-H)	E140 Drift at S1456 (Roof-to-Floor)	6/23/98
Convergence Points	R	E140-S1534-2 (A-E, B-D, H-F)	E140 Drift at S1534 (Roof-to-Floor)	6/23/98
Convergence Points	R	E140-S1600-5 (A-C)	E140 Drift at S1600 (Roof-to-Floor)	6/23/98
Convergence Points	R	E140-S1687-2 (A-E, B-D, H-F)	E140 Drift at S1687 (Roof-to-Floor)	6/23/98
Convergence Points	R	E140-S1775-2 (A-G, B-F, L-H)	E140 Drift at S1775 (Roof-to-Floor)	6/23/98
Convergence Points	R	E140-S1862-2 (A-E, B-D, H-F)	E140 Drift at S1862 (Roof-to-Floor)	6/23/98
Convergence Points	R	E140-S1917-3 (A-C)	E140 Drift at S1917 (Roof-to-Floor)	6/23/98
Convergence Points	R	E140-S1950-4 (A-C)	E140 Drift at S1950 (Roof-to-Floor)	6/23/98

N = New instrument.
R = Replacement instrument (i.e., instrument replaces older instrument that has failed or has been mined out).

5.4 *Analysis of Convergence Data*

Convergence data are obtained by measuring the change in distance between fixed points anchored into the rock. Convergence measurements are a primary means of identifying areas where conditions may be becoming unstable. These measurements are made, at a minimum, every two months throughout the repository. Convergence rates indicate how an excavation is performing; rates that decrease or are constant typify stable excavations, whereas increasing convergence rates may indicate some type of developing instability.

Routinely, convergence rates are plotted against time, and comparisons are made between consecutive rates of convergence to identify any acceleration. Points that indicate an acceleration are then analyzed to determine the significance of the acceleration. Factors that are considered during the analysis include the magnitude of the respective rates, percentage increase, convergence history, and any recent excavation in the vicinity.

A total of 415 radial convergence point pairs throughout the underground repository were examined during this reporting period. Of these 415 pairs of convergence points, 19 pairs of points have calculated annual convergence rates that were 10 percent higher than the calculated rates for the same pairs from the previous reporting period. Fourteen of these 19 convergence point pairs are located in access drifts. Of these 14, seven measure vertical (roof-to-floor) convergence and the other seven measure horizontal (rib-to-rib) convergence. The remaining five convergence point pairs are located in Panel 1 of the Waste Disposal Area (Chapter 7.0). Table 5-4 presents the 14 access drift locations that exhibited a greater than a 10-percent increase in convergence rate relative to the previous reporting period.

Further analysis of these accelerations has shown many of them to be relatively insignificant. When the running median of the convergence rate was analyzed for these 14 pairs, only three of the pairs showed a trend of increasing convergence rates over the long-term median convergence rate. These three pairs are located in S90 drift at W590 (vertical convergence points), S90 drift at W770 (horizontal convergence points), and N215 drift at W500 (horizontal convergence points). Even with the relative increases ranging from 12 to 15 percent, all three of these locations continue to have low annual convergence rates (less than 2.5 cm/year [yr] [1 in./yr]). The increases in convergence rates at these locations may be caused by the trimming and scaling activities that were completed in the S90 drift area in September 1997.

Table 5-4
Increases in Convergence Rates
Access Drifts

Fieldtag	Date Excavated	Convergence Rate 6/95 to 6/96 cm/yr (in./yr)	Convergence Rate 6/96 to 6/97 cm/yr (in./yr)	Convergence Rate 6/97 to 6/98 cm/yr (in./yr)	Increase in Convergence Rate[a] % increase
Vertical Convergence Point Pairs (Roof-to-Floor)					
W30-S1453 (A-C)	8/30/84	1.72 (0.68)	1.71 (0.67)	2.06 (0.81)	20.4
E300-S1000 (A-C)	7/18/84	1.43 (0.56)	1.29 (0.51)	1.55 (0.61)	19.6
S90-W590 (A-C)	11/15/87	1.53 (0.60)	1.66 (0.65)	1.91 (0.75)	15.0
S90-W400 (A-C)	12/3/87	1.59 (0.63)	1.54 (0.61)	1.77 (0.70)	14.8
W30-S1775 (A-C)	2/14/86	1.23 (0.49)	1.31 (0.51)	1.45 (0.57)	11.4
E140-S1600-4 (A-C)	12/20/82	ND	3.43 (1.35)[b]	3.81 (1.50)	11.2
S1300-E120 (A-C)	8/13/84	ND	2.33 (0.92)[b]	2.58 (1.01)	10.4
Horizontal Convergence Point Pairs (Rib-to-Rib)					
W30-S250-5 (B-D)	10/30/82	1.9[illegible] (0.76)	1.82 (0.72)	2.22 (0.88)	22.2
W30-S500 (B-D)	8/3/84	1.93 (0.76)	1.82 (0.72)	2.14 (0.84)	17.2
W170-S232-2 (B-D)	8/7/84	1.84 (0.72)	1.37 (0.54)	1.55 (0.61)	12.9
S90-W770 (B-D)	11/7/88	1.96 (0.77)	1.77 (0.70)	2.00 (0.79)	12.8
N215-W500 (B-D)	12/31/87	2.18 (0.86)	2.10 (0.83)	2.36 (0.93)	12.2
W170-S850-3 (C-G)	8/17/84	1.59 (0.62)	1.51 (0.59)	1.67 (0.66)	11.0
W30-S850 (C-G)	8/14/84	1.64 (0.65)	1.65 (0.65)	1.83 (0.72)	10.8

[a] Increase in convergence rate is calculated from the difference between the 1996–1997 rate and the 1997–1998 rate.

[b] Convergence rate is calculated on a period of less than 1 year.

cm/yr = centimeter(s) per year.

in./yr = inch(es) per year.

ND = No data is available for this instrument during this period.

5.5 Excavation Performance

Bimonthly assessments of underground excavations continue to indicate that convergence rates vary with seasonal temperature variations; typically increasing during the warmer summer months and decreasing during the cooler winter months. Over 400 readings are collected and assessed from convergence point pairs located throughout the WIPP underground on a regular basis.

The performance of the access drift excavations during this reporting period was within acceptable criteria. Only standard remedial ground control maintenance was required to maintain the performance of the excavations.

6.0 Performance of Northern Experimental Area

This chapter describes the geomechanical performance of the rooms and access drifts located in the Northern Experimental Area. This area includes all excavations north of the N1100 drift including the SPDV rooms, the N1400 and N1100 drifts, the E0 and E140 drifts between N1100 and N1400, and the E300 shop. This area has been deactivated. Deactivation of this area precludes direct observation of instruments or the installation of new instruments; therefore, only data from remotely read instruments are available for analysis.

6.1 Modifications to Excavation and Ground Control Activities

Access to this area was blocked in August and September 1996 by the construction of barriers in the E0 and E140 drifts at N800; therefore, no modifications or ground control activities were performed in this area during this reporting period.

6.2 Instrumentation

Active, remotely read, geotechnical instrumentation located in the Northern Experimental Area consists of borehole extensometers and wire convergence meters. Figure 6-1 shows the locations of the active and inactive instruments in the Northern Experimental Area.

6.2.1 Borehole Extensometers

Data were collected remotely from seven extensometers located in the Northern Experimental Area during this reporting period. Table 6-1 presents the collar displacement relative to the deepest anchor for each of these extensometers at the end of this reporting period.

6.2.2 Wire Convergence Meters

Twenty-three wire convergence meters were monitored remotely during this reporting period.

6.3 Excavation Performance

Within the Northern Experimental Area, SPDV Room 4, Rooms L3 and L4, drifts E0 and E140, Room D, the E300 shop, and the east end of drifts N1100 and N1400 are regularly monitored for performance. Based on the extensometer and wire convergence meter data, the closure rates within most of these monitored rooms and drifts continues to be relatively constant (Table 6-2). One area near the west rib in SPDV Room 4 at approximately N1250 is exhibiting increases in closure rates in both the wire convergence meter and the borehole extensometer located there. Section 6.4 discusses these increases in detail.

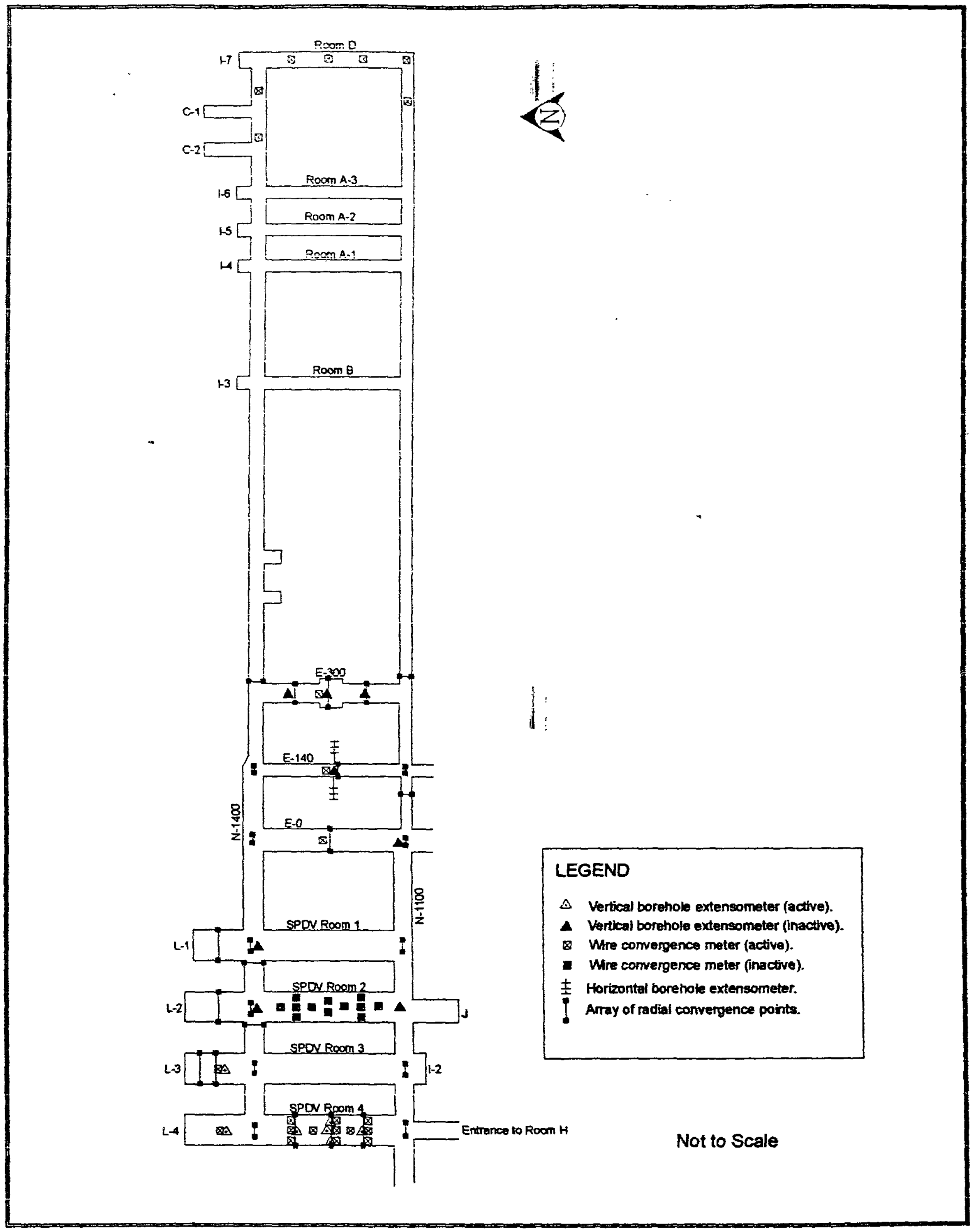


Figure 6-1
Location of Active and Inactive Geotechnical Instruments in the Northern Experimental Area

Table 6-1
Results of Remotely Read Extensometers in the Northern Experimental Area

Location		Date of Initial Reading	Date of Last Reading	Collar Displacement Relative to Deepest Anchor (cm)	(in.)
Room L3	Roof	9/20/95	6/19/98	9.573	3.769
Room L4	Roof	9/20/95	6/19/98	2.238	0.881
SPDV Room 4-N1325	Roof	12/15/95	6/19/98	4.859	1.913
SPDV Room 4-N1250	East 1/4 Pt	12/15/95	6/19/98	2.484	0.978
SPDV Room 4-N1250	Roof	12/15/95	6/19/98	3.861	1.520
SPDV Room 4-N1250	West 1/4 Pt	12/15/95	6/19/98	5.834	2.297
SPDV Room 4-N1175	Roof	12/21/95	6/19/98	2.621	1.032

cm = centimeter(s)
in. = inch(es)
Pt. = point
SPDV = Site Preliminary Design Validation Program

Table 6-2
Annual Vertical Convergence Rates in the Northern Experimental Area

Location	Convergence Rate 6/96 to 6/97 cm/yr (in./yr)	Convergence Rate 6/97 to 6/98 cm/yr (in./yr)	Increase in Convergence Rate % Increase (or decrease)
SPDV Room L3	5.51 (2.17)	5.74 (2.26)	4.3
SPDV Room L4	7.00 (2.76)	7.57 (2.98)	8.2
SPDV Room 4 at center	4.60 (1.81)	4.78 (1.88)	3.9
E0 Drift between N1100 and N1420	7.31 (2.88)	7.43 (2.92)	1.6
E140 Drift between N1100 and N1420	4.92 (1.94)	4.98 (1.96)	1.2
E300 Shop at center	8.56 (3.37)	8.26 (3.25)	-3.6
N1100 at E1530	1.55 (0.61)	1.52 (0.60)	-1.9
N1420 at E1551	2.14 (0.84)	2.06 (0.81)	-3.6
Room D at center	2.97 (1.17)	2.44 (0.96)	-18.0

cm/yr = centimeters per year
in./yr = inches per year
SPDV = Site Preliminary Design Validation Program

6.4 Analysis of Convergence Data

As described in Section 5.3, convergence measurements are a primary means of identifying areas where conditions may be becoming unstable. The convergence data collected for excavations in the Northern Experimental Area indicate that most of these excavations remain stable, with the exception of SPDV Room 4 indicating an area of possible developing instability. The extensometer located in the roof of SPDV Room 4 at N1250 (room center) near the west rib has shown a 52 percent increase in the rate of collar movement during the 1996-1997 reporting period relative to the 1995-1996 reporting period and an increase of 37 percent in collar movement rate during this reporting period relative to the 1996-1997 period. Readings from the wire convergence meter located in the same area indicate a much lower convergence rate, 11 percent over the previous reporting period (1996-1997). The convergence rate for this location for the present reporting period, based on the wire convergence meter data, is 7.32 cm/yr (2.88 in./yr). The collar displacement rate from the extensometer data is 2.93 cm/yr (1.15 in./yr). This area will be monitored closely for further indications of possible instability in the roof beam. The convergence rates in the remaining rooms and drifts are relatively constant with rates ranging from 2.0 to 8.0 cm/yr (0.8 to 3.1 in./yr).

Because the E0 and E140 drifts are barricaded at N800, the seasonal variations in closure rates observed throughout the WIPP underground excavation are absent from measurements taken in the Northern Experimental Area.

7.0 Performance of Waste Disposal Area

Excavation of the waste disposal area began in May 1986 with the mining of entries to Panel 1. Initially, the disposal rooms and drifts were developed as pilot drifts that were later excavated to 4 m (13 ft) high, 10 m (33 ft) wide, and 91 m (300 ft) long. Room 1 was excavated to these dimensions in August 1986, and pilot drifts for Rooms 2 and 3 were excavated in January and February 1987. Rooms 2 and 3 were excavated to final dimensions in February and March 1988 and Rooms 4 through 7 were completed in May 1988. Short access drifts designed to lead to smaller test alcoves were excavated north off of the S1600 drift in June 1989. Only the access drifts to the alcoves were completed; the alcoves were not excavated.

7.1 Modifications to Excavations and Ground Control Activities

No new excavations were mined in the Waste Disposal Area during the reporting period of July 1997 through June 1998. Routine maintenance was performed on ribs, floor, and roof; and supplemental ground support systems were installed in portions of S1600 and S1950 drifts and Rooms 4 and 7. Table 7-1 summarizes the ground control activities performed in the Waste Disposal Area during this reporting period.

Table 7-1

Summary of Modifications and Ground Control Activities in the Waste Disposal Area July 1, 1997 through June 30, 1998

Date Completed	Work Performed
Trimming and Milling Activities	
June 1998	Floor trimming of S1950 drift between E300 and Room 1.
Ground Control Activities	
July 1997	Installation of 39 3.7-m (12-ft) threaded bars, 70 1.2-m (4-ft) rockbolts, 12 panels of 1.5x4.3 m (5x14 ft) welded wire mesh, and 61 m (200 ft) of 2.5-m (8-ft) wire mesh along 23 m (75 ft) S1950 drift between E400 and Room 1.
October 1997	Installation of 20 1.2-m (4-ft) rockbolts in S1950 drift between Rooms 4 and 5.
February 1998	Installation of supplemental cable support system consisting of 580 4-m (13 ft) threaded bar rods, 205 1.2-m (4-ft) rockbolts, and 2,700 m (8,900 ft) of 1.6-cm (5/8-in.) diameter steel cable, in the east ends of S1600 and S1950 drifts and Room 7.
March 1998	Installation of 102 1.2-m (4-ft) rockbolts, 28 panels of 1.5x4.3 m (5x15 ft) welded wire mesh, 76 3 m(10 ft) threaded bar rods, and 38 steel cable slings in the center 50 m (150 ft) of Room 4.
June 1998	Installation of 90 1.2-m (4-ft) rockbolts and 142 m (465 ft) of 2.5-m (8-ft) welded wire mesh in Room 2.

cm = centimeter(s)
ft = foot (feet)
in. = inch(es)
m = meter(s)

7.2 Instrumentation

New extensometers were installed in the roofs of each of the seven rooms of Panel 1 during this reporting period. One convergence point array was installed in S1950 drift between Rooms 6 and 7, and two convergence point sets were replaced in S1600 and S1950 drift entries (between E300 and Room 1) in September 1997. Two wire convergence meters were replaced near the center of Room 6 in late May 1998. Table 7-2 lists locations within Panel 1 where new instruments were installed or where instruments were replaced during this reporting period. Figure 7-1 shows the location of the various types of geotechnical instruments in Panel 1 of the Waste Disposal Area.

The 286 rockbolt load cells of the yielding roof support system in Room 1 are monitored regularly and are detensioned as needed. As the roof tries to move down, the load supported by the rockbolts increases. Scheduled detensioning of the rockbolts is performed approximately every five weeks to maintain the load supported by the rockbolt within a specified range that allows the roof beam to continue to move. As part of the design of the yielding roof support system, the loads on these rockbolts are typically maintained between approximately 22 and 89 kilonewtons (5,000 and 20,000 lb). However, nine of the rockbolts have reached their maximum adjustment point. The load on these nine bolts can no longer be kept below the 89-kilonewton (20,000-lb) level. Loads on these bolts currently range from 107 kilonewtons (24,000 lb) to 200 kilonewtons (45,000 lb). Details on the design of the Room 1 yielding roof support system are found in "Waste Isolation Pilot Plant Supplementary Roof Support System, Underground Storage Area, Panel 1, Room 1," (DOE, 1991). The "Long Term Ground Control Plan for the Waste Isolation Pilot Plant," (Westinghouse WID, 1997) provides information on the status of the roof support system.

7.3 Excavation Performance

In order to collect early convergence data, convergence points were installed at selected locations immediately following initial excavation. Horizontal and vertical convergence rates have been calculated at the center of each of the rooms in Panel 1 for the past three reporting periods. Tables 7-3 and 7-4 present these convergence rates. The vertical convergence rates at the center of each of the rooms in Panel 1 has either remained constant or decreased during the current reporting period relative to each of the two previous reporting periods. The horizontal convergence rates at each room center has also remained relatively constant during the current reporting period relative to the previous period with minor increases in Rooms 2, 3, 4, and 5.

Table 7-2

New and Replaced Instrumentation in the Waste Disposal Area
July 1, 1997 through June 30, 1998

Instrument Type	N/R	Field Tag	Location	Date Installed
Borehole Extensometer	R	51X-GE-00332 (replaces 51X-GE-01022)	Room 7, Panel 1, north roof	6/11/97
Borehole Extensometer	R	51X-GE-00331 (replaces 51X-GE-01021)	Room 7, Panel 1, center roof	7/7/97
Borehole Extensometer	N	51X-GE-00330	Room 7, Panel 1, south roof	7/9/97
Borehole Extensometer	N	51X-GE-00327	Room 6, Panel 1, south roof	7/25/97
Borehole Extensometer	N	51X-GE-00328	Room 6, Panel 1, center roof	7/31/97
Borehole Extensometer	N	51X-GE-00329	Room 6, Panel 1, north roof	8/13/97
Borehole Extensometer	N	51X-GE-00324	Room 5, Panel 1, south roof	8/25/97
Borehole Extensometer	N	51X-GE-00325	Room 5, Panel 1, center roof	9/9/97
Borehole Extensometer	N	51X-GE-00326	Room 5, Panel 1, north roof	9/16/97
Borehole Extensometer	N	51X-GE-00321	Room 4, Panel 1, south roof	10/2/97
Borehole Extensometer	N	51X-GE-00322	Room 4, Panel 1, center roof	10/13/97
Borehole Extensometer	N	51X-GE-00323	Room 4, Panel 1, north roof	10/23/97
Borehole Extensometer	N	51X-GE-00318	Room 3, Panel 1, south roof	11/3/97
Borehole Extensometer	N	51X-GE-00319	Room 3, Panel 1, center roof	11/11/97
Borehole Extensometer	N	51X-GE-00320	Room 3, Panel 1, north roof	11/26/97
Borehole Extensometer	N	51X-GE-00315	Room 2, Panel 1, south roof	12/2/97
Borehole Extensometer	N	51X-GE-00316	Room 2, Panel 1, center roof	12/5/97
Borehole Extensometer	N	51X-GE-00317	Room 2, Panel 1, north roof	12/9/97
Borehole Extensometer	R	51X-GE-00312 (replaces 51X-GE-01017)	Room 1, Panel 1, south roof	12/19/97
Borehole Extensometer	R	51X-GE-00313 (replaces 51X-GE-01018)	Room 1, Panel 1, center roof	1/20/98
Borehole Extensometer	R	51X-GE-00314 (replaces 51X-GE-01019)	Room 1, Panel 1, north roof	2/5/98
Convergence Points	N	S1950-E1250 (A-E, B-D, C-G, H-F)	S1950 Drift at E1250	7/17/97
Convergence Points	R	S1950-E311-3 (B-D)	S1600 Drift entry at E311	9/22/97
Convergence Points	R	S1600-E586-3 (A-C)	S1950 Drift at E586	9/23/97
Wire Convergence Meter	R	51X-CW-01021-1 (Roof-to-Floor)	Room 6, Panel 1, north of center	5/28/98
Wire Convergence Meter	R	51X-CW-01022-1 (Roof-to-Floor)	Room 6, Panel 1, south of center	5/28/98

N = New instrument.

R = Replacement instrument (instrument replaces older instrument that has failed or has been mined out).

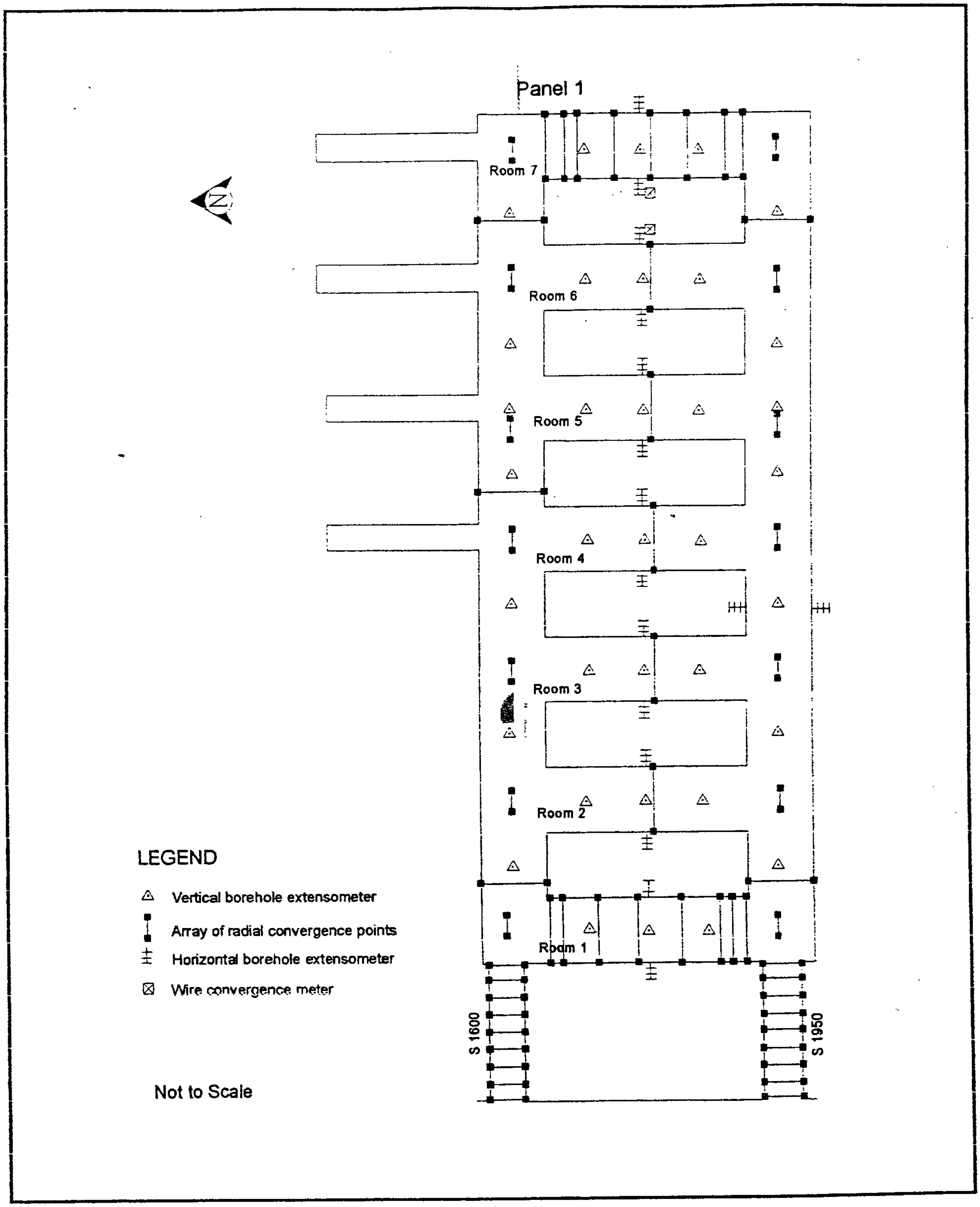


Figure 7-1

Location of Geotechnical Instruments in the Waste Disposal Area

Table 7-3
Annual Vertical Convergence Rates at the Center of Each Waste Disposal Room

Location		Fieldtag	1995-1996 Convergence Rate cm/yr (in./yr)	1996-1997 Convergence Rate cm/yr (in./yr)	1997-1998 Convergence Rate cm/yr (in./yr)
Room 1	Centerline	E520-S1802-6 A-E	8.92 (3.51)	7.89 (3.11)	6.79 (2.67)
Room 2	Centerline	E660-S1775-5 A-C	5.57 (2.19)	5.72 (2.25)	5.64 (2.22)
Room 3	Centerline	E790-S1775-3 A-C	6.91 (2.72)	7.76 (3.05)	6.32 (2.49)
Room 4	West of centerline	E920-S1775-5 A-F	6.60 (2.60)	5.88 (2.32)	5.40 (2.13)
Room 4	East of centerline	E920-S1775-4 B-E	4.89 (1.93)	4.42 (1.74)	4.14 (1.63)
Room 5	West of centerline	E1050-S1775-4 A-F	5.83 (2.30)	5.94 (2.34)	5.52 (2.17)
Room 5	East of centerline	E1050-S1775-4 B-E	6.17 (2.43)	5.99 (2.36)	5.32 (2.10)
Room 6	West of centerline	E1190-S1775-4 A-F	7.15 (2.81)	6.00 (2.36)	5.50 (2.17)
Room 6	East of centerline	E1190-S1775-3 B-E	7.46 (2.94)	5.89 (2.32)	5.41 (2.13)
Room 7	West of centerline	E1320-S1775-3 A-F	6.12 (2.41)	5.80 (2.28)	ND[a]
Room 7	East of centerline	E1320-S1775-4 B-E	5.94 (2.34)	5.79 (2.28)	ND[a]
Room 7	East of centerline	E1320-S1775 A-E	ND[a]	ND[a]	6.65 (2.62)[a]

[a] Convergence point pairs for Room 7 center were replaced in June 1997. New convergence point pair is located at room centerline.

cm/yr = centimeter(s) per year

in./yr = inch(es) per year

ND = No data

Table 7-4
Annual Horizontal Convergence Rates at the Center of Each Waste Disposal Room

Location		Fieldtag	1995-1996 Convergence Rate cm/yr (in./yr)	1996-1997 Convergence Rate cm/yr (in./yr)	1997-1998 Convergence Rate cm/yr (in./yr)
Room 1	Rib center	E520-S1802-3 C-G	3.60 (1.42)	3.49 (1.37)	3.35 (1.32)
Room 2	Rib center	E660-S1775-5 B-D	3.10 (1.22)	3.06 (1.21)	3.19 (1.26)
Room 3	Rib center	E790-S1775-5 B-D	4.02 (1.58)	4.29 (1.69)	4.33 (1.70)
Room 4	Above rib center	E920-S1775-5 C-H	3.83 (1.51)	3.85 (1.52)	3.76 (1.48)
Room 4	Below rib center	E920-S1775-5 D-G	3.74 (1.47)	3.70 (1.46)	3.72 (1.47)
Room 5	Above rib center	E1050-S1775-5 C-H	3.41 (1.34)	3.68 (1.45)	3.75 (1.48)
Room 5	Below rib center	E1050-S1775-5 D-G	3.37 (1.33)	3.72 (1.46)	3.71 (1.46)
Room 6	Above rib center	E1190-S1775-4 C-H	2.95 (1.16)	3.17 (1.25)	3.16 (1.24)
Room 6	Below rib center	E1190-S1775-4 D-G	2.95 (1.16)	3.24 (1.27)	3.22 (1.27)
Room 7	Above rib center	E1320-S1775-5 C-H	3.11 (1.22)	3.14 (1.24)	ND[a]
Room 7	Below rib center	E1320-S1775-5 D-G	3.23 (1.27)	3.17 (1.25)	ND[a]
Room 7	Rib center	E1320-S1775 C-G	ND[a]	ND[a]	3.48 (1.37)

[a] Convergence point pairs for Room 7 center were replaced in June 1997. New convergence point pair is located at rib centerline.

cm/yr = centimeter(s) per year

in./yr = inch(es) per year

ND = No data

Fracturing within the immediate roof beam contributes to high convergence rates seen in some areas of Panel 1, especially portions of Room 1. Fracture mapping in Panel 1 is discussed in Chapter 8 and detailed fracture mapping results are presented in the "Geotechnical Analysis Report for July 1997–June 1998 Supporting Data" document. The ground support systems in Rooms 1 and 2, Panel 1 are designed specifically to yield in response to deformation and, therefore, have no significant effect on the rate of roof displacement. However, if the roof fracturing increases to the point at which a large section of the rock is detached, the yielding support systems are designed to support the weight of the roof beam (Westinghouse WID, 1997). Convergence rates within Room 1, Panel 1 have decreased during this reporting period at 19 of the 22 locations monitored. If conditions in Room 1 adversely change, the ground support system will be upgraded or adjusted as necessary, or the room will be abandoned.

7.4 Analysis of Convergence Data

As discussed in Section 5.3, convergence rates are plotted against time, and comparisons are made between consecutive rates of convergence to identify any acceleration. Points that indicate an acceleration are then analyzed to determine the significance of the acceleration. Factors that are considered during the analysis include the magnitude of the respective rates, percentage increase, convergence history, and any recent excavation in the vicinity.

A total of 415 radial convergence point pairs throughout the underground facility were examined during this reporting period. Of these 415 pairs of convergence points, 19 different pairs of points have calculated annual convergence rates that were more than 10 percent greater than the calculated annual convergence rates for the same convergence point pairs from the previous reporting period. Five of these 19 convergence point pairs are located in Panel 1 with the remaining 14 pairs located in access drifts (Section 5.3). Table 7-5 presents the convergence rate, taken as the difference in convergence measurements between June 1997 and June 1998, and the percentage increase in convergence rate for each of these five locations. The convergence rates from the 1995-1996 and the 1996-1997 reporting periods are also presented for these locations. All five of the convergence point pairs are located in the S1950 drift between E140 and Room 1. These increases in convergence rates may indicate some possible excavation instability in this area. The S1950 drift will continue to be closely monitored for any additional increase in convergence rate and will be evaluated to determine whether there is a need for a supplemental ground support system.

Table 7-5
Increases in Vertical and Horizontal Convergence Rates
Panel 1

Fieldtag	Date Room Excavated	Convergence Rate 6/95 to 6/96 cm/yr (in./yr)	Convergence Rate 6/96 to 6/97 cm/yr (in./yr)	Convergence Rate 6/97 to 6/98 cm/yr (in./yr)	Increase in Convergence Rate [a] % increase
Vertical Convergence Points					
S1950-E281-2 (A-C)	11/25/85	2.31 (0.91)	2.00 (0.79)	2.34 (0.92)	16.9
S1950-E503-4 (A-C)	5/19/86	5.13 (2.02)	5.07 (1.99)	5.84 (2.30)	15.4
S1950-E382-3 (A-C)	5/6/86	3.26 (1.28)	3.36 (1.32)	3.75 (1.48)	11.5
Horizontal Convergence Points					
S1950-E382-3 (B-D)	5/6/86	2.29 (0.90)	2.27 (0.90)	2.58 (1.02)	13.6
S1950-E357-3 (B-D)	5/2/86	2.13 (0.84)	2.15 (0.85)	2.37 (0.93)	10.2

[a] Increase in convergence rate is calculated from the difference between the 1996–1997 rate and the 1997–1998 rate.

cm/yr = centimeter(s) per year.

in./yr = inch(es) per year.

8.0 Geoscience Program

The Geoscience Program confirms the suitability of the site through the collection of geologic data from the underground facility, including documentation of the stratigraphy and excavation characteristics. Geologic data is gathered through the mapping of excavation surfaces and logging of rock cores obtained from boreholes. Excavation characteristics are determined from fracture mapping and the logging of fractures and offsets (lateral displacements) in open boreholes. Data collected through these activities support the design and evaluation of ground support systems (Westinghouse WID, 1997).

During this reporting period, the following activities were performed:

- Inspections of subsurface fractures and offsets in boreholes
- Mapping of fractures on excavation surfaces
- Logging of cores.

8.1 Borehole Inspections

Geotechnical observation boreholes are drilled at various locations throughout the underground facility. A location may contain one or several boreholes arranged in an array. These holes are drilled to depths that allow the monitoring of fracture development and offsetting and are inspected for the development of those features.

Roof observation holes usually intersect clays G and H; while floor observation holes usually intersect only clay E (Figure 8-1). The clay seams nearest the excavation surfaces define the immediate roof and floor beams. Clay G defines the roof beam in most of the access drift and disposal areas, while clay E defines the floor beam. Some areas, such as the Salt Handling Shaft Station and portions of the E140 drift are excavated to clay G and so have roof beams bounded by clay H.

The offset in a borehole is determined by visually estimating the degree of borehole occlusion. The direction of offset along clay seams is observed as the movement of the strata nearer to the observer relative to the strata farther away. Typically the nearer strata moves toward the center of the excavation (Figure 8-2). Based on previous observations in the underground, the magnitude of offset is usually greater in boreholes located near ribs than in those located along

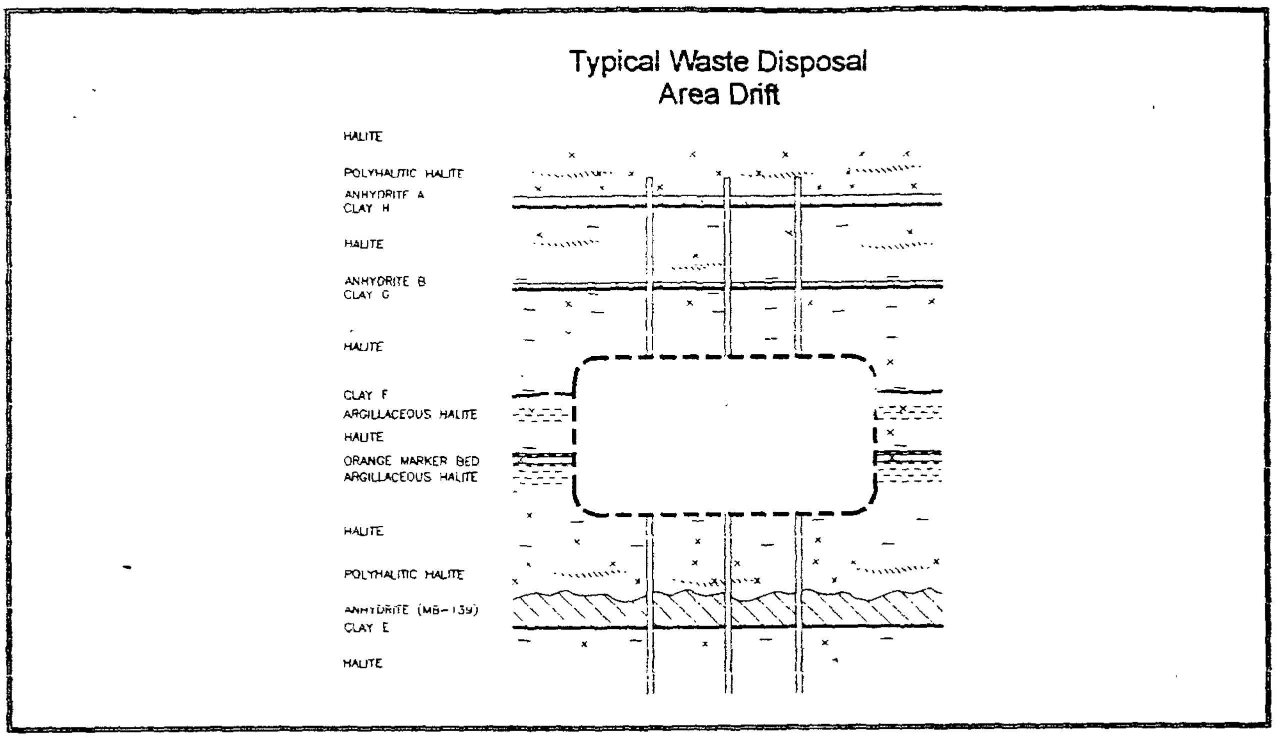


Figure 8-1

Examples of Observation Borehole Layouts

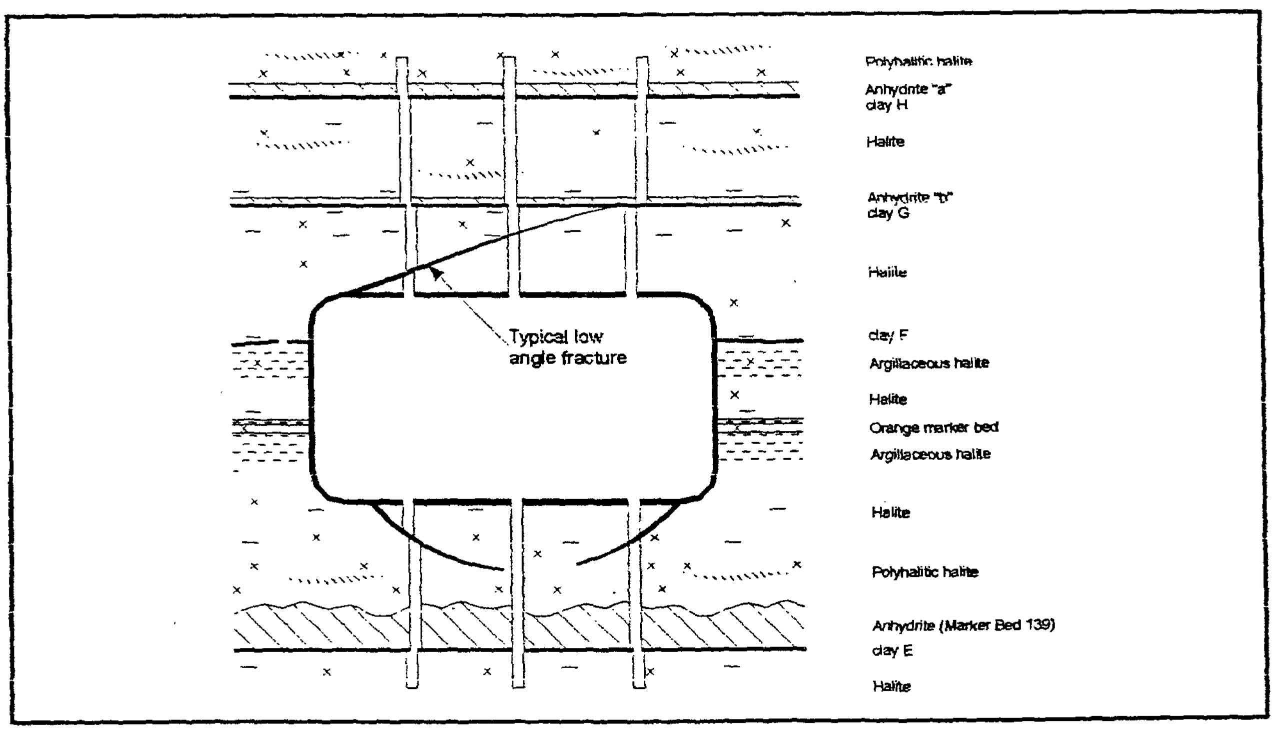


Figure 8-2

Generalized Fracture Pattern

excavation centerlines. Offsetting along the clay layers is observable until the total borehole offset is reached or visibility is obstructed by intervening offsets at other clay seams or fractures. Boreholes are inspected for fractures using an aluminum rod with a flattened steel wire probe attached to one end perpendicular to the rod (referred to as a "scratcher rod"). Fractures and clay seams are located by moving the probe along the sides of the borehole until it is snagged in one of these features. Depth to each feature is recorded, as is the magnitude of separations encountered.

The separation and offset data observed at clay G and clay H in accessible boreholes during this reporting period are presented in the supporting data document for this report.[3] In the floor, observations of clay seam offset are often precluded by intervening offsets along fractures or by holes becoming filled with crushed salt. There is no separation or offset data for clay E for this reporting period.

8.2 Fracture Mapping of Excavation Surfaces

Fracture mapping is conducted to document the length, width, and orientation of fractures on excavation surfaces. Fractures in the roof surface in the rooms and entry drifts of Panel 1 were mapped during this reporting period. The fracturing of the roof surface in these rooms and drifts can then be compared to the fracture mapping performed in the same areas during the 1995-1996 reporting period to determine the extent of fracture expansion and new fracturing over the two-year period. A detailed summary of the fracture mapping results is presented in the supporting data document for this report.

8.3 Geologic Core Logging

Cores are logged to determine the geology in selected areas or to document the location of geologic features for the placement of instruments. Core logging consists of providing a physical description of the stratigraphy and a photographic record of the core. A total of 80 new boreholes were drilled and logged during this reporting period. Twenty-two of these holes were intended for the installation of extensometers while the remaining 58 boreholes were drilled as observation holes. A detailed summary of core logging activity performed during this reporting period is presented in the supporting data document for this report.

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[3] Instrumentation data and data plots are available in "Geotechnical Analysis Report for July 1997-June 1998 Supporting Data." This document is available upon request from Westinghouse, Waste Isolation Division. Refer to Foreword and Acknowledgements for details and address.

9.0 Summary

At the inception of the WIPP project, criteria were developed that address the requirements for the design of the WIPP (DOE, 1984). These criteria, in the form of design requirements, pertain to all aspects of the mined facility and its operation as a pilot plant for the demonstration of technical and operational methods for permanent disposal of CH- and remote handled-TRU waste. In 1994, as the WIPP developed and the focus moved toward the permanent disposal of TRU waste, these design requirements were reassessed and replaced by a new set of requirements called system design descriptions (SDD). Table 9-1 shows the comparison of these SDDs with conditions actually observed in the underground from July 1997 to June 1998.

Fracture development in the roof is primarily caused by the concentration of compressive stresses in the roof beam and is influenced by the size and shape of the excavation and the stratigraphy in the immediate vicinity of the opening. Pillar deformations induce lateral compressive stresses into the immediate roof and floor. With time the buildup of stress causes differential movement along stratigraphic boundaries. This differential movement is identified as offsets in observation boreholes and is indicated by the bends in failed rockbolts. Large strains associated with lateral movements can induce fracturing in the roof, which is frequently seen near the ribs. This scenario of roof deterioration, combining compressive stresses, horizontal offsetting, and large strains associated with lateral movements, is substantiated by earlier observations of similar roof deterioration in SPDV Room 1, SPDV Room 2, and the E140 drift between S1000 and S1950.

Normal drift and room maintenance continued during this reporting period with floor trimming in several areas including the E140 drift (trimmed in preparation for transporting of waste to Panel 1), rib and roof scaling and trimming in various locations, and rockbolting and meshing as needed. Supplemental ground support systems consisting of cable slings were installed in the east ends of S1600 and S1950 drifts and in Room 7, Panel 1, and in the center of Room 4, Panel 1. A ground support system consisting of 4-m (13-ft) long rockbolts was installed in the roof of the E300 Maintenance Shop and adjoining office area.

New convergence point pairs were installed in portions of the E140 drift and in various locations throughout the repository to replace mined out instruments. Additional borehole extensometers were installed in each of the seven rooms in Panel 1 to continue to monitor the roof deformation

Table 9-1
Comparison of Excavation Performance to System Design Descriptions

System Design Description	Requirement	Comments
SDD-UH00, Underground Hoisting, Section 2.1.2.6.3	"The lining shall be designed for a hydrostatic pressure. . . ."	Water pressure observed on piezometers located behind the shaft keys in the Waste Shaft and the Exhaust Shaft remains below design levels.
Section 2.1.2.6.4	"The key shall be designed to resist the lateral pressure generated by salt creep."	Geomechanical data from the Waste Shaft indicate that the shaft is structurally stable. Extensometers located in the Salt Handling Shaft and the Exhaust Shaft were not functioning during this reporting period. Historic data indicate that closure of all the shafts remains within design requirements. Data from the Air Intake Shaft indicate it is performing within design requirements[a,b]. Visual inspections of the shaft keys indicate that they are performing satisfactorily.
Section 2.1.2.8	"The key shall be designed to retain the rock formation and will be provided with chemical seal rings and a water collection ring with drains to prevent water from flowing down the unlined shaft from the lining above."	The small amount of groundwater inflow into the shafts is effectively controlled through grouting. Seepage into the Exhaust Shaft is manageable and the source and content of such seepage are being characterized[c,d].
SDD-AU00, Underground Facilities and Equipment, Section 2.2.1.2, Underground Disposal Facilities	"The underground waste disposal facilities shall be designed to provide space and adequate access for the underground equipment and temporary storage space to support underground operations."	Geomechanical instrument data and visual observations indicate that the current design provides adequate access and storage space.
Section 2.2.1.2, Underground Disposal Facilities (Continued)	"The underground waste disposal facilities shall be designed to provide the capability of retrieving the emplaced CH and RH TRU waste."	Retrievability is not presently a requirement in the waste disposal program.

Table 9-1 (Continued)
Comparison of Excavation Performance to System Design Descriptions

System Design Description	Requirement	Comments
Section 2.2.1.3, Underground Shaft Pillar Facilities	"Entries and sub-entries to the underground disposal area and the experimental areas shall be provided and sized for personnel safety, adequate air flow, and space for equipment."	Deformation of excavation remains within the required limits. Normal periodic maintenance consisting of rockbolting, wire meshing, trimming, and scaling continue throughout the repository.
SDD-EM00, Environmental Monitoring, Section 2.2.5.1	"Geomechanical instrumentation shall be provided to measure the cumulative deformation of the rock mass surrounding mined drifts. . . ."	Geotechnical instrumentation is operated and maintained to meet this requirement. Additional geotechnical instruments were installed in various parts of the WIPP underground (including the E140 drift and Rooms 1 through 7 of Panel 1) during this reporting period. Geotechnical experts agree that the monitoring program at the WIPP has been proven adequate, specifically with regard to the instrumentation in Room 1, Panel 1[e].

[a] Munson, D.E., D.L. Hoag, J.R. Ball, G.T. Baird, and R.L. Jones, 1995, "AIS Performance Tests, (Shaft V): In situ Data Report (May1988 - July 1995)," SAND94-1311, Sandia National Laboratories, Albuquerque, New Mexico.

[b] Holcomb, D.J., 1997, Memorandum to J.R. Tillerson dated September 29, 1997, "Summary of Air Intake Shaft Measurements (October 1, 1996 – September 30, 1997), WBS 1.1.03.6.1; Completion of Milestone RM103, Summary Memo of FY97 AIS Measurements," Sandia National Laboratories, Albuquerque, New Mexico.

[c] Intera, 1997, "Exhaust Shaft Hydraulic Assessment Data Report," DOE/WIPP 97-2219, prepared for Westinghouse Waste Isolation Division by Intera, Albuquerque, New Mexico.

[d] IT Corporation, 1997, "Composition and Origin of Nonindigenous Brine and Water in the Vicinity of the Exhaust Shaft, Waste Isolation Pilot Plant, New Mexico," DOE/WIPP 97-2226, prepared for Westinghouse Waste Isolation Division by International Technology Corporation, Albuquerque, New Mexico.

[e] U.S. Department of Energy, 1991b, "Report of the Geotechnical Panel on the Effective Life of Rooms in Panel 1," DOE/WIPP 91-023, Waste Isolation Pilot Plant, Carlsbad, New Mexico.

CH = contact handled

RH = remote handled

TRU = transuranic

WIPP = Waste Isolation Pilot Plant

in this area. The barricaded portion of the E140 drift, south of S2180, was entered in March 1998 to assess the ground conditions in this area. Remotely read wire convergence meters were installed during this assessment. The drift was found to be in good condition with no indications of roof falls or excessive instability.

The in situ performance of the excavations generally continues to satisfy the appropriate design criteria, although specific areas are being identified where deterioration resulting from aging must be addressed through routine maintenance and implementation of engineered systems. This deterioration has been identified through the analysis of data acquired from geomechanical instrumentation and the Geoscience Program (Chapter 8.0). If the planned life of some of the openings needs to be extended, redesigning the geometry of the access drifts (e.g. changing the horizontal and vertical dimensions) or additional ground control (e.g. installing bolts, mesh, or slings) may be necessary.

In addition to underground instrumentation, qualitative assessments of fracture development are documented through mapping the underground repository and inspecting the observation boreholes. The information acquired from these programs provides early detection of ground deterioration, contributes to the understanding of the dynamic geomechanical processes in the WIPP underground, and aids in the design of effective ground control and support systems.

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