UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

SEP 26 2001

OFFICE OF
AIR AND RADIATION

Inés Triay, Manager
Carlsbad Field Office
U.S. Department of Energy
P.O. Box 3090
Carlsbad, NM 88221-3090

Dear Dr. Triay:

As you know, the Environmental Protection Agency (EPA) conducted three inspections at the Waste Isolation Pilot Plant (WIPP) site from June 19 - 21, 2001. These inspections were conducted under the authorities of 40 CFR 194.21 and 40 CFR Part 191, Subpart A, and examined waste emplacement, monitoring, and waste management and storage. I am pleased to provide you with the inspection reports. We will also place these reports in EPA's Air Docket A-98-49.

We have determined that the waste emplacement and waste management and storage activities that we inspected were consistent with the activities and commitments identified in the Department of Energy's (DOE's) Compliance Certification Application (CCA). During the monitoring inspection, we were unable to verify that the Subsidence Monitoring Program has an implemented, effective quality assurance program as committed to in the CCA. DOE must resolve this finding to our satisfaction. Please respond to this finding within 30 days of receipt of this letter.

Please direct your response to this finding and any questions to Chuck Byrum at 214-665- Thank you for your cooperation during the inspections.

Sincerely

Frank Marcinowski, Director
Radiation Protection Division

Enclosure

Cindy Zvonar, DOE
Matthew Silva, EEG

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DOCKET NO: A-98-49
Item: II-B3-18
(#3)

Monitoring Inspection Report

INSPECTION No. EPA-WIPP-6.01-21c
OF THE
WASTE ISOLATION PILOT PLANT
June 20-21, 2001

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

September 2001

Table of Contents

1.0 Executive Summary 1

2.0 Scope 1

3.0 Inspection Team, Observers, and Participants 2

4.0 Performance of the Inspection 3

4.1 Monitoring of Geomechanical Parameters 3

4.2 Monitoring of Hydrological Parameters 4

4.3 Monitoring of Waste Activity Parameters 4

4.4 Monitoring of Drilling Related Parameters 4

4.5 Monitoring of Subsidence Parameters 5

5.0 Summary and Results 6

5.1 Finding 6

<u>Attachments</u>

Attachment A	Inspection Plan and Checklist
Attachment B	Opening and Closing Sign Up Sheets
Attachment C	Documents Reviewed
Attachment D.1	Geomechanical Documents Reviewed
Attachment D.2	Hydrological Documents Reviewed
Attachment D.3	Waste Activity Documents Reviewed
Attachment D.4	Drilling Related Documents Reviewed
Attachment D.5	Subsidence Documents Reviewed
Attachment D.6	Other Documents Reviewed

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 20-21, 2001, 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 the 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 programs at WIPP for all but one area. The EPA had one finding regarding the verification that the Subsidence Monitoring has an implemented effective Quality Assurance Program. The inspection team also confirmed that DOE monitoring programs are reported annually.

2.0 Scope

40 CFR Part 194.42(a) 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's 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. 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 and verified implementation of an effective quality assurance program.

3.0 Inspection Team, Observers, and Participants

The inspection team consisted of two representatives of the EPA Administrator. An observer from the Environmental Evaluation Group (EEG), Jim Kenney, was 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	Organization	Affiliation
Casey Gadbury		DOE/CBFO
Richard Farrell		DOE/CBFO
Stan Patchet	General Engineering	WTS
Jack Gilbert	Mine Manager	DOE
Ron Richardson	ES&H	WTS
Ken Mikus	Waste Ops	WTS
Stewart Jones	ES&H	WTS
Rey Carrasco	Geo. Engr.	WTS
Dave Speed	WWIS	WTS
Gary Maples	Subsidence	WTS

WTS = Westinghouse CBFO = Carlsbad Field Office ES&H = Environmental Safety and Health
WWIS =WIPP Waste Information System

The inspection began on Wednesday, June 19, 2001, with a presentation by DOE/CBFO and WTS. Katherine Knowls (SNL) discussed the present status of the Culebra water level changes (Attachment D.6, COB_M2001-3).

The inspection team reviewed various activities to verify effective implementation of the plans and procedures. Nick Stone (EPA) 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/WTS year 2001 Environmental Monitoring Sampling Schedule is in Attachment D.6 (COB_M2001-4b).

4.0 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 provides details of inspection activities.

4.1 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 (Attachment D.1, COB_M2001-D).

The results of the Geotechnical Engineering Program are documented in the Geotechnical Analysis Report for July 1998 - June 1999 (Attachment D.1,COB_M2001-A).

Inspectors toured and reviewed underground instrumentation, the computer database, and field data sheets used to record raw measurement data (Attachment D.1, COB_M2001-P and COB-M2001-Q). They also examined the input of data into the computer database and examined the output QA checkprints (Attachment D.1, COB_M2001-P) to verify implement of the measurement plan.

4.2 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 (Attachment D.2, COB_M2001-C).

The results of this program are documented in the Waste Isolation Pilot Plant Site Environmental Report - Calendar Year 1999 (Selected samples included in this inspection report, Attachment D.2, COB_M2001-O). This document describes the groundwater monitoring program and presents results during the year.

DOE/WTS staff presented a detailed explanation of groundwater composition measurement procedures, such as dissolved minerals (Attachment D.2, COB-M2001-V).

4.3 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 Program and System Data Management Plan (WP 08-NT.01, Attachment D.3, COB_M2001-G).

The facility demonstrated that the WWIS can receive data and that the WWIS can generate reports. The CBFO 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 _M2001-AA through COB_M2001-AG).

4.4 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_M2001-F). 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 1999 through September 2000 (Attachment D.4, COB_M2001-N) and in a quarterly report.

Inspectors reviewed the drilling surveillance database, examined drilling rate changes, and permitted and active injection wells. The inspection received a list of changes in drilling rates from 1996 to 2001 (Attachment D.4, COB_M2001-W) and a list from the well database of permitted and active injection wells (Attachment D.4, COB_M2001-X). Inspectors were also provide a copy of a list that shows the corresponding state engineer well file numbers for wells at WIPP (Attachment D.4, COB_M2001-Y). In addition inspectors received a list of " Castile Brine Encounters" (Attachment D.4, COB_M2001-Z).

4.5 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 (Attachment D.5, COB_M2001-B). 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_M2000-E).

The inspection team examined how horizontal and vertical surveys are performed. Inspectors also examined the steps taken to perform a survey, 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 (Attachement D.5, COB_M2001-R), raw field data (COB_M2001-S) and Leveling Data Summary spreadsheet (COB_M2001-T). The inspector also received a copy of "Interim FGCS Specifications and Procedures to Incorporate Electronic Digital/Bar Code Leveling Systems" (COB-M2001-U) which is an industry standard used for performing surface surveys.

During the interviews with subsidence monitoring staff the inspection requested objective evidence that the survey program is controlled by an effective implemented quality assurance program. Subsidence monitoring staff were not able to produce such documentation, therefore the lack of evidence that this program has an implemented quality assurance program is an inspection finding.

5.0 Summary and Results

Inspectors concluded that DOE has adequately maintained programs to monitor the necessary ten parameters during pre-closure operations, except for the subsidence monitoring program. DOE/WTS reports the results of these monitoring activities as specified in the CCA.

5.1 Finding.

Inspectors found that the subsidence monitoring program at WIPP was not able to show that it had an implemented effective quality assurance program during the inspection. DOE/WTS is required to respond to this finding. The inspection had no other findings, concerns, or observations.

Attachment A: Inspection Plan and Checklist

WIPP Monitoring Inspection Plan - 40 CFR 194.42 for the year 2001

Purpose: Verify that the Department of Energy (DOE) can demonstrate that the Waste Isolation Pilot Plant (WIPP) is monitoring the parameter commitments made in the documentation to support the EPA's certification decision, in particular CCA, Volume 1, Section 7.0 and Appendix MON. This inspection is conducted under the authority of 40 CFR 194, Section 21.

This inspection is part of EPA's continued oversight to ensure that WIPP can, in fact, monitor the performance of significant parameters of the disposal system.

Scope: Inspection activities will include an examination of monitoring and sampling equipment both on and off site, and in the underground. A review of sampling procedures and measurement techniques may be conducted. Quality assurance procedures and documentation for each of these activities may also be reviewed.

Location: This inspection will be held at the WIPP facility location twenty-six miles south east of Carlsbad, New Mexico and the surrounding vicinity as needed.

Duration: The EPA expects to complete its inspection in one day. The day will begin with an opening meeting at 8:00 a.m. and end at 5:00 p.m. with a closeout session.

Date: Expected to be held during June 21, 2001.

Inspection Focus: The inspection will focus on three areas. The possible impact of recent water level changes in Culebra monitoring wells. The inspectors expect DOE and WID to present analyses of how these changes impact the Culebra groundwater composition and the groundwater flow direction. The inspectors also expect the DOE and WID to provide a discussion of any plans to evaluate and remedy these anomalous changes in the Culebra.

Secondly the inspection will review in detail drilling rate parameters, in particular the inspectors will evaluate any changes in drilling rates and Castile brine pocket encounters during the past year.

Lastly, the inspection will review geomechanical parameters to evaluate changes in creep closure, extent of deformation, and other related changes in Panel Two, the newly reworked experimental area, and any recent changes to Panel One

40 CFR 194.42 - 2001 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)	COB_M2001-D documents the program planned to measure, document, report, and QA these four activities. Section 3.0, COB_M2001-D 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, COB_M2001-D documents the quality assurance requirements of these activities. COB_M2001-P and COB_M2001-Q are examples of raw data collection and verification. COB_M2001-A 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 May 2001 and found the program at DOE/WTS adequate.	Sat.
3	Does DOE demonstrate that the results of the geotechnical investigations are reported annually? (CCA, App. MON, Page MON-10)	COB_M2001–D, page 8 requires that analysis will be performed annually and the results will be published in the geotechnical analysis report.	Sat.

Documents Reviewed:
#8 - COB_M2001-D: WIPP Geotechnical Engineering Program Plan - WP 07-01, Revision 2
#21 - COB_M2001-P: Sample - raw data - GIS Field Data Sheets, Room Closure Measurements
#22 - COB_M2001-Q: Sample - raw data - Convergence work sheet and plot
#5 - COB_M2001-A: Geotechnical Analysis Report for July 1998 - June 1999

40 CFR 194.42 - 2001 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)	COB_M2001-C, below, documents the program planned to measure, document, report, and QA these two activities. COB_M2001-C 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 12.0, COB_M2001-C documents the quality assurance requirements of these activities. COB_M2001-V is an example of data collection related to hydrological parameter measurement. COB_M2001-O 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 May 2001, and found the program at DOE/WTS adequate.	Sat.
3	Does DOE demonstrate that the results of the groundwater monitoring program are reported annually? (CCA, App. MON, Page MON-22)	COB_M2001-C, page 40 documents that results of monitoring will be reported annually and will be published in the Annual Site Environmental Report (ASER).	Sat.

Documents Reviewed:
#7 - COB_M2001-C: Groundwater Monitoring Program Plan - WP 02-1, Revision 5, 11/17/99
#27 - COB_M2001-V: Samples of various water chemistry measurements
#20 - COB_M2001-O: Waste Isolation Pilot Plant Site Environmental Report - Calendar Year 1999 selected samples

40 CFR 194.42 - 2001 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. COB_M2001-G documents the program planned to measure, document, report, and QA this activity. COB_M2001-G documents the WWIS Program and records the activities associated with this program, the methods planned to be used, and the reporting plans. Items #32 through #38 are examples of the many reports that can be generated using the WWIS. 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 May 2001, and found the program at DOE/WTS adequate.	Sat.
3	Does DOE demonstrate that the results of the waste activity parameters are reported annually? (CCA Volume, Section 7.2.4 Reporting)	COB_M2001-G, page 10 documents that results of monitoring will be reported annually.	Sat.

Documents Reviewed:
#11 - COB_M2001-G: WIPP Waste Information Program and System Data Management Plan - WP 08-NT.01, Revision 4
#32 - COB_M2001-AA: Sample - WWIS Shipment Summary Report
#33 - COB_M2001-AB: Sample - WWIS Waste Emplacement Report
#34 - COB_M2001-AC: Sample - WWIS Repository Report
#35 - COB_M2001-AD: Sample - WWIS Repository Report
#36 - COB_M2001-AE: Sample - WWIS Waste Container Data Report
#37 - COB_M2001-AF: Sample - WWIS Biennial Report
#38 - COB_M2001-AG: Sample - WWIS Nuclide Report

40 CFR 194.42 - 2001 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)	COB_M2001-F, documents the program planned to measure, document, report, and QA these two activities. COB_M2001-F 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, COB_M2001-F documents the quality assurance requirements of these activities. COB_M2001-W and COB_M2001-X are examples of data generated by the drilling related monitoring program. COB_M2001-N is an example of the information produced from the surveillance database. COB_M2001-N is a copy of the annual report; page 8 shows the 2000 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 May 2001, and found the program at DOE/WTS 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)	COB_M2001-F, page 5 documents that results of monitoring will be reported annually.	Sat.

Documents Reviewed:
#10 - COB_M2001-F: Delaware Basin Drilling Surveillance Plan - WP 02-PC.02, Revision 0
#28 - COB_M2001-W: Change in drilling intrusion rate from 1996 to 2001
#29 - COB_M2001-X: List of permitted and active injection wells near WIPP
#19 - COB_M2001-N: Delaware Basin Drilling Surveillance Program - Annual Report for October 1998 through September 1999

40 CFR 194.42 - 2001 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)	COB_M2001-B documents the program planned to measure, document, report, and QA these two activities. COB_M2001-B 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, COB_M2001-B documents the quality assurance requirements of these activities. COB_M2001-E is a copy of the annual report for 1999. COB_M2001-R, -S, and -T are a samples of raw data collected during the subsidence survey and computational worksheets. The inspection team toured and reviewed the computer and database system used to record and store subsidence survey data.	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 May, 2001 and found the program at DOE/WTS adequate. However, during the monitoring inspection EPA inspectors could find produce documentation that shows that DOE has an effective QA program implemented.	UnSat. **Finding**
3	Does DOE demonstrate that the results of the subsidence measurements are reported annually? (CCA Volume, Section 7.2.4 Reporting)	COB_M2001-B, page 2 documents that results of monitoring will be reported annually.	Sat.

Documents Reviewed:
#6 - COB_M2001-B: WIPP Underground and Surface Surveying Program - WP 09-ES.01, Revision 2
#23 - COB_M2001-R: Sample - raw survey data - Digital Leveling Log Sheet
#24 - COB_M2001-S: Raw Data from field measurements
#25 - COB_M2001-T: Leveling data summary
#9 - COB_M2001-E: WIPP Subsidence Monument Leveling Survey - 2000, October 2000

Attachment B:
Opening and Closing Meeting Attendance Sheets

EPA CCA INSPECTION
JUNE 19, 20, 21, 2001

Tuesday June 10, 2001

Printed Name	Signature	Organization
Verla Martin	Verla Martin	WTS/QA
Larry J Madl	Larry J Madl	WTS/ES&H
Stewart B. Jones	Stewart B. Jones	WTS/ES&H/EM
Mark E. Crawley	Mark Crawley	WTS/ES&H/EM
Ron RON RICHARDSON	Ron Richardson	WTS/ES&H/EM
Marshal L. Beekman	Marshal L. Beekman	WTS/ES&H/RT
STANLEY J. PATCHET	[signature]	WTS GEOTECH ENG
GARY R. MAPLES	Gary Maples	WTS MINE ENG
SUBHASH SETHI	[signature]	WTS/OPS.
KIM JACKSON	K Jackson	WTS/WH Ops
Bruce Lilly	Bruce Lilly	DOE/CBFO
Richard Farrell	Richard Farrell	DOE/CBFO
Jim Kenney	Jim W. Kenney	EEG
Wes Root	Wes Root	WTS/ES&H
STEVE CASEY	[signature]	WTS/REQUIREMENTS MANAGEMENT
Russell H. Patterson	[signature]	DOE/CBFO
Harold Johnson	Harold Johnson	DOE/CBFO
[illegible]	[signature]	WTS-ES&H
DAVID REBER	[signature]	WTS-OPS
Mike DAUGHERTY	Mike Daughert	CBFO
H.L. "JODY" PLUM	[signature]	CBFO/ORC
DARYL MERCER	Daryl Mercer	CBFO/ORC
Linda Frank-Supka	Linda Frank-Supka	WTS/ES&H
Tom Pfeifle	Tom W. Pfeifle	SNL
Randy Roberts	R Roberts	SNL
Casey Gadbury	[signature]	CBFO/OSQ
Dave Kump	D. R. Kump	WTS/ES&H

Opening Meeting
COB_A2001-AB

EPA CCA INSPECTION
JUNE 19, 20, 21, 2001

Tuesday June 10, 2001

Printed Name	Signature	Organization
Nick Stone	Nick Stone	EPA
Chuck Byrum	Charles O Byrum	EPA
Katherine Knowles		Sandia
Ines Triay		CBFO

EPA CCA INSPECTION
DAILY CLOSE-OUT MEETING

Tuesday June 19, 2001

Printed Name	Signature	Organization
H W BELLOWS	H W Bellows	OPS/WTS
Jim Kenney	Jim Kenney	EEG
Bill Bartlett	W B Bartlett	CTAC
S. B. Jones	S B Jones	WTS/ES&H/EM
H. Johnson	Harold Johnson	CBFO
Wes Root	Wes Root	WTS/ES&H
Verla Martin	Verla Martin	WTS/QA
Kim Jackson	[illegible]	WTS/Waste Handling Ops
Russ Patterson	Russell P	DOE/CBFO
Larry Madl	Larry Madl	WTS/ES&H
Richard Farrell	Richard Farrell	DOE/CBFO
Don Harward	J. Harward	WTS/ES&H
Dave Kump	D A Kump	WTS/ES&H
CANDICE Tierree	C Junie	WTS-ESH

EPA CCA INSPECTION
DAILY CLOSE-OUT MEETING

Wednesday June 20, 2001

Printed Name	Signature	Organization
S.B Jones	S.B. Jones	WTS / ES&H / EM
Jim Kenney	Jim Kenney	EEG
Larry Madl	Larry L Madl	WTS / ES&H
Bill Bartlett	B Bartlett	CTAC
S.J Patchet	S Patchet	WTS Geotech Eng
R C Carrasco	Ray Carrasco	WTS Geo Engr.
Wes Root	Wesley Root	WTS /ES&H
M.L. Beekman	M.L. Beekman	WTS/ES&H
HW Bellows	HW Bellows	WTS /OPS
KA Jackson	K Jackson	WTS/OPS
H.L. Penn	[illegible]	DOE/CBFO/ORC
Richard Farrell	Richard Farrell	
Candice Jierree	C Jierree	WTS-ESH
Dave Kump	D.R. Kump	WTS/ES&H

EPA CCA INSPECTION

Close-Out Meeting

Date June 21, 2001

PRINTED NAME	SIGNATURE	ORGANIZATION
Verla Martin		WTS/QA
Bill Bartlett		CTAC
Jim Kenney		EEG
Larry Madl		WTS/ES&H
DAVID HUGHES		WTS/ES&H
RON RICHARDSON		WTS/ES&H
Wes Root		WTS/ES&H
S. J. PATCHET		WTS Geotech Eng
L. A. PYEATT		WTS Mine Eng
[illegible] R. MAPLES		WTS Mine Eng
Bruce Lilly		DOE/CBFO
Richard Farrell		DOE/CBFO
[illegible] "Toby" Perm		DOE/CBFO/ORC
Larry Bailey		DOE/CBFO
D.C. Gadbury		DOE/CBFO
Russ Patterson		DOE/CBFO
Nick Stone		EPA
Chuck Byrum		EPA
Jack Gilbert		DOE

COB_A2001-AC

EPA CCA INSPECTION

Close-Out Meeting

ate June 21, 2001

PRINTED NAME	SIGNATURE	ORGANIZATION
H W Bellows	H W Bellows	WTS/OPS
Harold Johnson	Harold Johnson	CBFO
SUBHASH SETHI	[signature]	WTS/OPS
DALE SPEED	[signature]	WTS/NTM
RAEBURN S. JOSEY	[signature]	WTS/LCSA
Linda Frank Supka	L Frank-Supka	WTS/ES&H
Dave Kump	D. R. Kump	WTS/ES&H
CANDICE JIERREE	C Jierree	WTS/ES&H
KIM JACKSON	[signature]	WTS/WHO
Don Harward	J. Harward	WTS/ES&H
KEN MIKUS	[signature]	WTS/WWIS
S. B Jones	S B Jones	WTS/ES&H

Attachment C: Documents Reviewed

	Documents Reviewed and Copies Received	194.42 Monitoring Inspection - June 2001	DOE Documents	
#	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_M2001-1	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 parameters selected to be monitored at the WIPP site. COB_M2001-2	DOE, CCA documentation. *Not included in this report	No*
3	Opening Meeting Presentation Materials	Water Level Changes in the Culebra, by Katherine Knowles COB_M2001-3	DOE/WTS Attachment D.6	Yes
4	Tentative Inspection Agenda and List of Contacts; Sample of 2001 Environmental Monitoring Sampling Schedule - June 2001 to December 2001	COB_M2001-4a and 4b	DOE/WTS Attachment D.6	Yes
5	Geotechnical Analysis Report for July 1998 - June 1999, DOE/WIPP-00-3177, 08/00	This report is an example of the results of the geomechanical monitoring program. COB_M2001-A	DOE/WTS Attachment D.1	Yes
6	Subsidence Monitoring: WIPP Underground and Surface Surveying Program WP 09-ES.01 Revision 2, 02/14/00	Demonstrates DOE's implementation of subsidence monitoring. COB_M2001-B	DOE/WTS Attachment D.5	Yes
7	Hydrological Monitoring: WIPP Groundwater Monitoring Program Plan WP 02-1 Revision 5, 11/17/99	Demonstrates DOE's implementation of hydrological monitoring. COB_M2001-C	DOE/WTS Attachment D.2 ^Selected Samples	Yes^

	Documents Reviewed and Copies Received	194.42 Monitoring Inspection - June 2001	DOE Documents	
#	Document Title	Subject Matter	Source and Location	Copy
8	Geomechanical Monitoring: WIPP Geotechnical Engineering Program Plan WP 07-01, Revision 2, 03/16/98	Demonstrates DOE's implementation of geomechanical monitoring. COB M2001-D	DOE/WTS Attachment D.1	Yes
9	WIPP Subsidence Monument Leveling Survey - 2000 DOE/WIPP 00-2293, October 2000	This report is an example of the results of the subsidence monitoring program. COB M2001-E	DOE/WTS Attachment D.5	Yes
10	Delaware Basin Drilling Surveillance Plan WP 02-PC.02, Revision 0, 03/27/97	Documents DOE's drilling monitoring plan. COB M2001-F	DOE/WTS Attachment D.4	Yes
11	WIPP Waste Information Program and System Data Management Plan WP 08-NT.01, Revision 4, 01/02/01	Demonstrates DOE's implementation of waste activity monitoring. COB M2001-G	DOE/WTS Attachment D.3	Yes

	Documents Reviewed and Copies Received	**194.42 Monitoring Inspection** - June 2001	**DOE Documents** Sample of implementation of drilling related monitoring requriements.	
#	Document Title	Subject Matter	Source and Location	Copy
13	Waste Stream Profile Form Review and Approval Program WP 08-NT.03 Revision 1, 10/20/00	Demonstrates DOE's implementation of waste activity monitoring. COB_M2001-H	DOE/WTS *Not included in this report.	No*
14	WIPP Waste Information System Configuration Management and Software Quality Assurance Program WP 08-NT.04, Revision 2, 10/09/00	Demonstrates DOE's implementation of waste activity monitoring. COB_M2001-I	DOE/WTS	No*
15	WIPP Waste Information System Software Verification and Validation Plan WP 08-NT.05, Revision 1, 10/31/00	Demonstrates DOE's implementation of waste activity monitoring. COB_M2001-J	DOE/WTS	No*
16	WIPP Waste Information Software Requirements Specification WP 08-NT.06, Revision 1, 10/31/00	Demonstrates DOE's implementation of waste activity monitoring. COB_M2001-K	DOE/WTS	No*
17	WIPP Waste Information System Software Design Description WP -08-NT.07, Revision 2, 01/25/01	Demonstrates DOE's implementation of waste activity monitoring. COB_M2001-L	DOE/WTS	No*

	Documents Reviewed and Copies Received	194.42 Monitoring Inspection - June 2001	DOE Documents	
#	Document Title	Subject Matter	Source and Location	Copy
18	WID Quality Assurance Program Description WP 13-1 Revision 19, 01/08/01	Demonstrates DOE's implementation of quality assurance program. COB_M2001-M	DOE/WTS *Not included in this report.	No*
19	Delaware Basin Drilling Surveillance Program - Annual Report for October 1999 Through September 2000 DOE/WIPP99-2308 Revision 1	Demonstrates DOE's implementation of drilling surveillance program. COB_M2001-N	DOE/WTS Attachment D.4	Yes
20	Waste Isolation Pilot Plant Site Environmental Report for 1999, September 2000 DOW/WIPP 99-2225	Example of the results of the environmental monitoring program, in particular hydrological parameters. COB_M2001-O	DOE/WTS ^Selected Samples. Attachment D.2	Yes^
21	Room Closure Measurements - Sample of Raw Data with plot of Extensometer measurements in Panel 2 Room 4	Demonstrates implementation of geomechanical monitoring program. COB_M2001-P	DOE/WTS Attachment D.1	Yes
22	Room Closure Measurements - Sample of Raw Data with plot of Convergence at S1950 Drift-E986 and a Convergence work sheet	Demonstrates implementation of geomechanical monitoring program. COB_M2001-Q	DOE/WTS Attachment D.1	Yes

	Documents Reviewed and Copies Received	194.42 Monitoring Inspection - June 2001	DOE Documents	
#	Document Title	Subject Matter	Source and Location	Copy
23	Sample - raw survey data - Digital Leveling Log Sheet (Loop)	Sample of implementation of subsidence monitoring program. COB_M2001-R	DOE/WTS Attachment D.5	Yes
24	Raw Data from field measurement (File: 255.raw) during subsidence data acquisition for survey point S43.	Sample of implementation of subsidence monitoring program COB_M2001-S	DOE/WTS Attachment D.5	Yes
25	Leveling Data Summary - Spreadsheet used to calculate height differences.	Sample of implementation of subsidence monitoring program. COB_M2001-T	DOE/WTS Attachment D.5	Yes
26	Interim FGCS Specification and Procedures to Incorporate Electronic Digital/Bar Code Leveling Systems (ver. 4.0 7/17/94)	Sample of implementation of subsidence monitoring program COB_M2001-U	DOE/WTS Attachment D.5	Yes
27	Samples of various water chemistry measurements.	Sample of implementation of hydrology monitoring requirements. COB_M2001-V	DOE/WTS Attachment D.2	Yes
28	Change in drilling intrusion rate from 1996 to 2001	Sample of implementation of drilling related monitoring requirements. COB_M2001-W	DOE/WTS Attachment D.4	Yes
29	List of permitted and active injection wells near WIPP.	Sample of implementation of drilling related monitoring requirements. COB_M2001-X	DOE/WTS Attachment D.4	Yes
30	List of WIPP Monitor Wells with Corresponding State Engineer File Numbers	Reference Only COB_M2001-Y	DOE/WTS Attachment D.4	Yes

	Documents Reviewed and Copies Received	194.42 Monitoring Inspection - June 2001	DOE Documents	
#	Document Title	Subject Matter	Source and Location	Copy
31	List from well database of Castile Brine Encounters	Sample of results of drilling related monitoring COB M2001-Z	DOE/WID Attachment D.4	Yes
32	Sample - WWIS Shipment Summary Report RP0390, Version 1.1	Sample report from the WWIS listing total activity on a drum by drum basis. COB M2001-AA	DOE/WID Attachment D.3	Yes
33	Sample - Waste Emplacement Report RO0440, Version 1.2	List the container number, site id, emplacement data, matrix code, etc for each drum. COB M2001-AB	DOE/WID Attachment D.3	Yes
34	Sample - Repository Report RP0530, Version 1.0	List the number of drums and standard waste boxes in the underground. COB M2001-AC	DOE/WID Attachment D.3	Yes
35	Sample - Repository Report RP0530, Version 1.0	List the number of drums and standard waste boxes in the underground. COB M2001-AD	DOE/WID Attachment D.3	Yes
36	Sample - Waste Container Data Report RP0360, Version 1.4	List specific details of contents and activity of each container. COB M2001-AE	DOE/WID Attachment D.3	Yes
37	Sample - Biennial Report RP0450, Version 1.0	List total weight in Kg of waste emplace. COB M2001-AF	DOE/WID Attachment D.3	Yes
38	Sample - Nuclide Report RP0380, Version 1.0	List weight and activity for 18 radionuclides with totals. COB M2001-AG	DOE/WID Attachment D.3	Yes

Attachment D.1:

Geomechanical Documents Reviewed

M

DOE/WIPP-00-3177

Geotechnical Analysis Report for July 1998 - June 1999

August 2000

WASTE ISOLATION PILOT PLANT

WIPP

C06_M2001-A

FOREWORD AND ACKNOWLEDGMENTS

This report contains an assessment of the geotechnical status of the Waste Isolation Pilot Plant (WIPP). During the excavation of the principal underground access and experimental areas, the status was reported quarterly. Since 1987, when the initial construction phase was completed, reports have been published annually. This report presents and analyzes data collected from July 1, 1998, to June 30, 1999.

This Geotechnical Analysis Report was written to meet the needs of several audiences. This report satisfies the requirements presented in the WIPP Hazardous Waste Permit[1] and the certificate of compliance with Title 40 *Code of Federal Regulations* (CFR) §§ 191 and 194. 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 investigations of excavation effects 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, 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.

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[1]New Mexico Environment Department (NMED), 1999, "Waste Isolation Pilot Plant Hazardous Waste Facility Permit," NM4890139088-TSDF, Santa Fe, New Mexico.

TABLE OF CONTENTS

FOREWORD AND ACKNOWLEDGMENTS iii

ACRONYMS AND ABBREVIATIONS x

1.0 INTRODUCTION 1
1.1 Location and Description 1
1.2 Mission 4
1.3 Development Status 4
1.4 Purpose and Scope of Geomechanical Monitoring Program 5
1.4.1 Instrumentation 6
1.4.2 Data Acquisition 7
1.4.3 Data Evaluation 8
1.4.4 Data Errors 8

2.0 GEOLOGY 11
2.1 Regional Stratigraphy 11
2.1.1 Castile Formation 11
2.1.2 Salado Formation 11
2.1.3 Rustler Formation 12
2.1.4 Dewey Lake Redbeds 13
2.1.5 Dockum Group 13
2.1.6 Gatuña Formation, Mescalero Caliche, and Surficial Sediments 13
2.2 Underground Facility Stratigraphy 14
2.2.1 Disposal Horizon Stratigraphy 14
2.2.2 Experimental Area Stratigraphy 16

3.0 PERFORMANCE OF SHAFTS AND KEYS 19
3.1 Salt Handling Shaft 19
3.1.1 Shaft Observations 19
3.1.2 Instrumentation 21
3.2 Waste Shaft 23
3.2.1 Shaft Observations 24
3.2.2 Instrumentation 26
3.3 Exhaust Shaft 29
3.3.1 Shaft Observations 30
3.3.2 Instrumentation 32
3.4 Air Intake Shaft 35
3.4.1 Shaft Performance 35
3.4.2 Instrumentation 35

4.0 PERFORMANCE OF SHAFT STATIONS 37
4.1 Salt Handling Shaft Station 37
4.1.1 Modifications to Excavation and Ground Control Activities 37
4.1.2 Instrumentation 37
4.2 Waste Shaft Station 41
4.2.1 Modifications to Excavation and Ground Control Activities 43
4.2.2 Instrumentation 43

4.3 Air Intake Shaft Station 46
4.3.1 Modifications to Excavation and Ground Control Activities 46
4.3.2 Instrumentation 47

5.0 PERFORMANCE OF ACCESS DRIFTS 49
5.1 Modifications to Excavation and Ground Control Activities 49
5.2 Instrumentation 49
5.2.1 Borehole Extensometers 49
5.2.2 Convergence Points 49
5.3 Analysis of Extensometer and Convergence Point Data 53
5.4 Excavation Performance 54

6.0 PERFORMANCE OF NORTHERN EXPERIMENTAL AREA 57
6.2 Entry into Deactivated Area 57
6.3 Instrumentation 57
6.3.1 Borehole Extensometers 57
6.3.2 Wire Convergence Meters 59
6.4 Excavation Performance 59
6.5 Analysis of Convergence Data 61

7.0 PERFORMANCE OF WASTE DISPOSAL AREA 63
7.1 Modifications to Excavations and Ground Control Activities 63
7.2 Instrumentation 64
7.3 Excavation Performance 66

8.0 GEOSCIENCE PROGRAM 69
8.1 Borehole Inspections 69
8.2 Fracture Mapping of Excavation Surfaces 71
8.3 Borehole Logging 72

9.0 SUMMARY .... 7310.0REFERENCES AND BIBLIOGRAPHY77
10.1 Cited References 77
10.2 Selected Bibliography 78

LIST OF TABLES

Table 1-1 Geomechanical Instrumentation System 7

Table 3-1 Collar Displacement at Waste Shaft Extensometers 26

Table 4-1 Vertical Closure Rates in the Salt Handling Shaft Station 41

Table 4-2 Historical Summary of Roof Extensometers in Waste Shaft Station . . . 46

Table 4-3 Vertical Closure Rates in the Waste Shaft Station 46

Table 5-1 Summary of Modifications and Ground Control Activities in the Access Drifts - July 1, 1998, Through June 30, 1999 50

Table 5-2 New and Replaced Convergence Points Installed in the Access Drifts - July 1, 1998, Through June 30, 1999 52

Table 5-3 Increases in Annual Vertical Convergence Rates of Greater than 10 Percent Access Drifts 55

Table 5-4 Increases in Annual Horizontal Convergence Rates of Greater than 10 Percent Access Drifts 56

Table 6-1 Results of Remotely Read Extensometers in the Northern Experimental Area 59

Table 6-2 Vertical Convergence Readings and Rates in the Northern Experimental Area Wire Convergence Meters 60

Table 7-1 Summary of Modifications and Ground Control Activities in the Waste Disposal Area - July 1, 1998, Through June 30, 1999 . . . 63

Table 7-2 Replaced Instrumentation in the Waste Disposal Area - July 1, 1998, Through June 30, 1999 64

Table 7-3 Annual Vertical Convergence Rates at the Center of Each Waste Disposal Room 67

Table 9-1 Comparison of Excavation Performance to System Design Descriptions 73

LIST OF FIGURES

Figure 1-1 WIPP Location 2
Figure 1-2 Current Underground Configuration 3
Figure 2-1 Regional Geology 11
Figure 2-2 Repository Level Stratigraphy 16
Figure 3-1 Salt Handling Shaft Stratigraphy 20
Figure 3-2 Salt Handling Shaft Instrumentation (Without Shaft Key) 22
Figure 3-3 Salt Handling Shaft Key Instrumentation 23
Figure 3-4 Waste Shaft Stratigraphy 25
Figure 3-5 Waste Shaft Instrumentation (Without Shaft Key) 27
Figure 3-6 Waste Shaft Key Instrumentation 29
Figure 3-7 Exhaust Shaft Stratigraphy 31
Figure 3-8 Exhaust Shaft Instrumentation (Without Shaft Key) 33
Figure 3-9 Exhaust Shaft Key Instrumentation 34
Figure 3-10 Air Intake Shaft Stratigraphy 36
Figure 4-1 Salt Handling Shaft Station Stratigraphy 38
Figure 4-2 Salt Handling Shaft Station Instrumentation Before Roof Beam Excavation 39
Figure 4-3 Salt Handling Shaft Station Instrumentation After Roof Beam Excavation 40
Figure 4-4 Waste Shaft Station Stratigraphy 42
Figure 4-5 Waste Shaft Station Instrumentation Before Wall Trimming 44
Figure 4-6 Waste Shaft Sation Instrumentation After Wall Trimming 45
Figure 5-1 Location of Geotechnical Instruments in the Access Drifts 51
Figure 6-1 Location of Active and Inactive Geotechnical Instruments in the Northern Experimental Area 58
Figure 7-1 Location of Geotechnical Instruments in the Waste Disposal Area . . . 64
Figure 8-1 Examples of Observation Borehole Layouts 70
Figure 8-2 Generalized Fracture Pattern 71
Figure 8-3 Sample Isometric Drawing of Fracture Mapping Data 72

ACRONYMS AND ABBREVIATIONS

b.p.	before present
CAO	Carlsbad Area Office
CFR	*Code of Federal Regulations*
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	geomechanical information system
in.	inch(es)
KPa	kilopascal(s)
lb	pound(s)
m	meter(s)
Ma	millions of years
MB	marker bed
NMED	New Mexico Environment Department
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
WID	Waste Isolation Division
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, 1998, to June 30, 1999. 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 (the access drifts, the Northern Experimental Area, and the Waste Disposal Area). Chapter 8.0 discusses the results of the Geoscience Program, which includes fracture mapping, borehole logging, 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

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 WIPP.

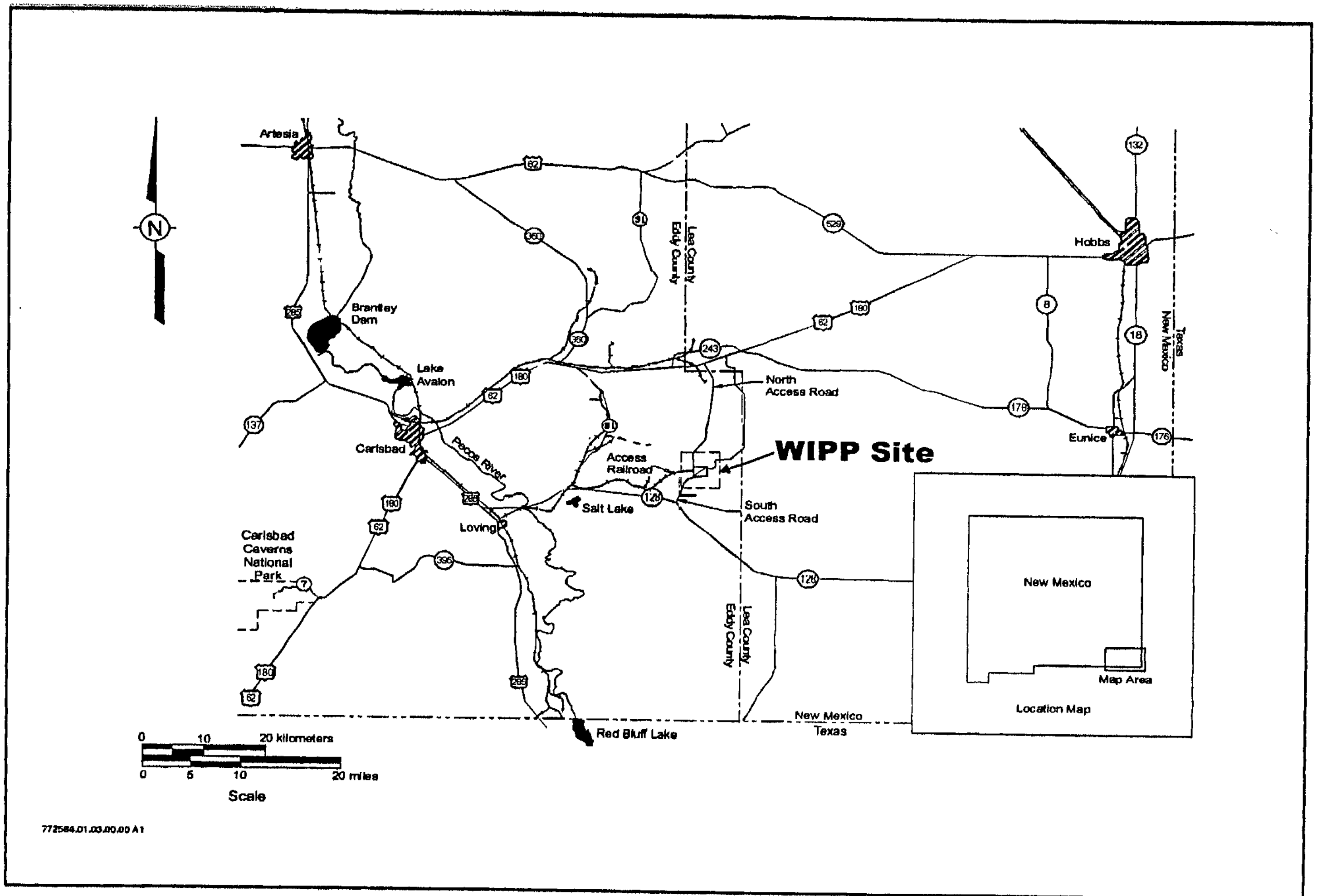

Figure 1-1 - WIPP Location

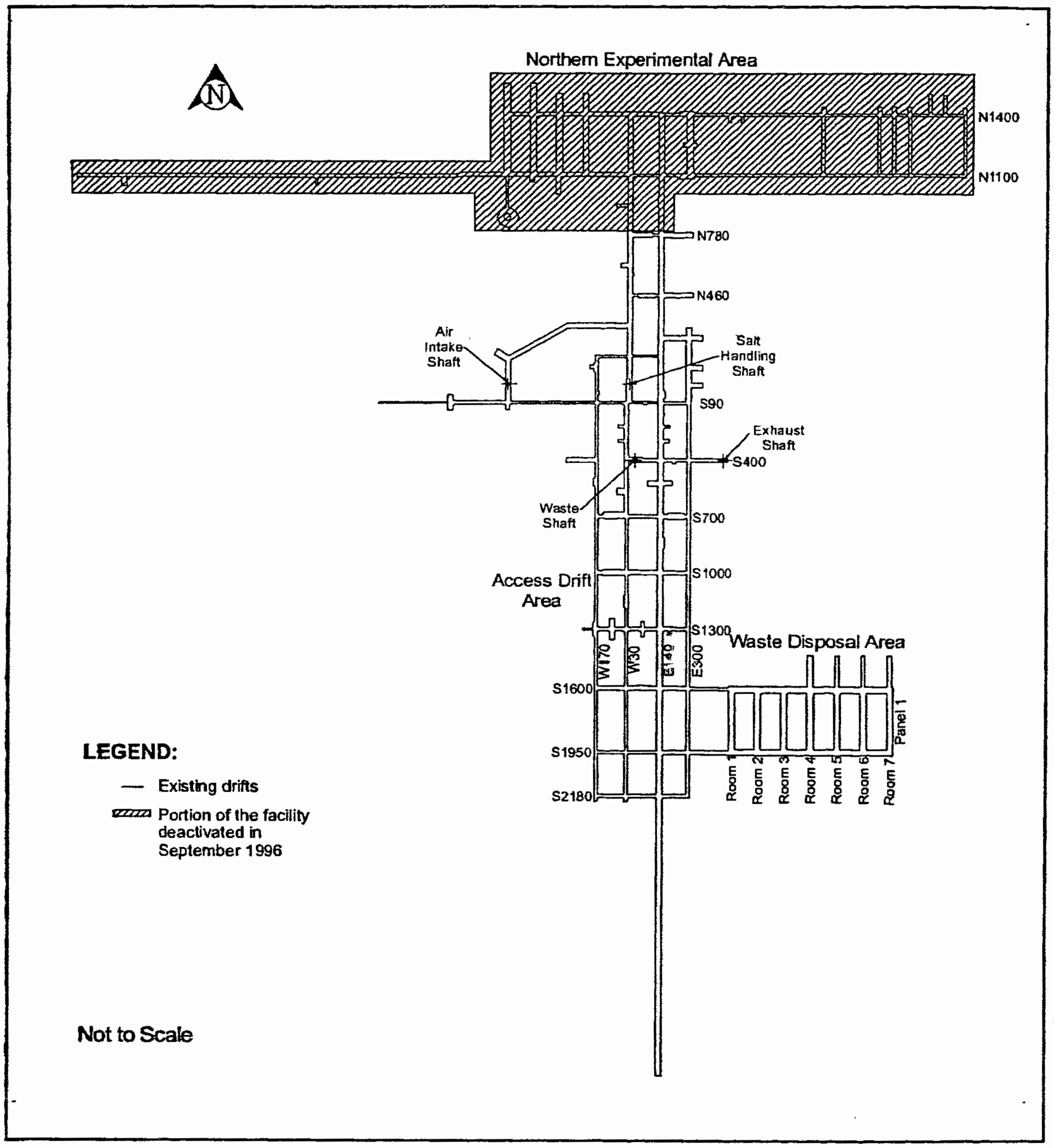

Figure 1-2 - Current Underground Configuration

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 five 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 safely accommodate 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 five 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, rock-bolts 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 seven 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 mixed TRU waste to 1999.

In October 1996, the DOE submitted to the U.S. Environmental Protection Agency (EPA) a compliance certification application in accordance with Title 40, Sections 191 and 194, of the Code of Federal Regulations, "Compliance Certification Application," which addressed the long-term (10,000-year) performance criterion for the disposal system. On May 13, 1998, the EPA issued final certification that allows for the receipt of TRU waste at the WIPP. Immediately prior to this certification, 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 the Energy Secretary on April 1, 1998, that the WIPP is operationally ready to receive waste. On March 26, 1999, the first shipment of TRU waste was received at the WIPP site from Los Alamos National Laboratory. By the end of April, 1999, shipments of TRU waste were being received at the WIPP site from both Los Alamos National Laboratory and Idaho National Engineering and Environmental Laboratory.

1.4 Purpose and Scope of Geomechanical Monitoring Program

As specified in the WIPP Hazardous Waste Permit (NMED, 1999), the purpose of the geomechanical monitoring program is to obtain in situ data to support the continuous assessment of the design for underground facilities. Specifically, the program provides for:

- Early detection of conditions that could affect operational safety
- Evaluation of disposal room closure that ensures adequate access
- Guidance for design modifications and remedial actions
- Data for interpreting the behavior of underground openings, in comparison with established design criteria.

Polling of the geomechanical instrumentation is performed at least monthly with higher frequency in some areas as deemed necessary. The data taken from the geomechanical instrumentation are evaluated and reported in this Geotechnical Analysis Report. This annual report fulfills the requirements set forth in Section IV.F.1 and Attachment M2, Section M2-5b(2) of the WIPP Hazardous Waste Permit (NMED, 1999), and 40 CFR § 191.14, "Assurance Requirements" implemented through the provisions of 40 CFR § 194.

The geomechanical instrumentation system (GIS) provides data that are collected, processed, and stored for analysis. The following subsections briefly describe 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, rock-bolt load cells, pressure cells, strain gauges, piezometers, and joint meters. Table 1-1 lists a summary of the geomechanical instrumentation specifications.

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.
Rock-bolt 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	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 have 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)

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.

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 versus time 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).

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

[1]Instrumentation data and data plots are available in "Geotechnical Analysis Report for July 1998-June 1999 Supporting Data." This document is available upon request from Westinghouse Waste Isolation Division. See Foreword and Acknowledgments for details and addresses.

- 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.

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 primarily 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 is 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 primary 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 rock-bolts 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 satisfactory condition. No ground control activities were required in the Salt Handling Shaft during this reporting period.

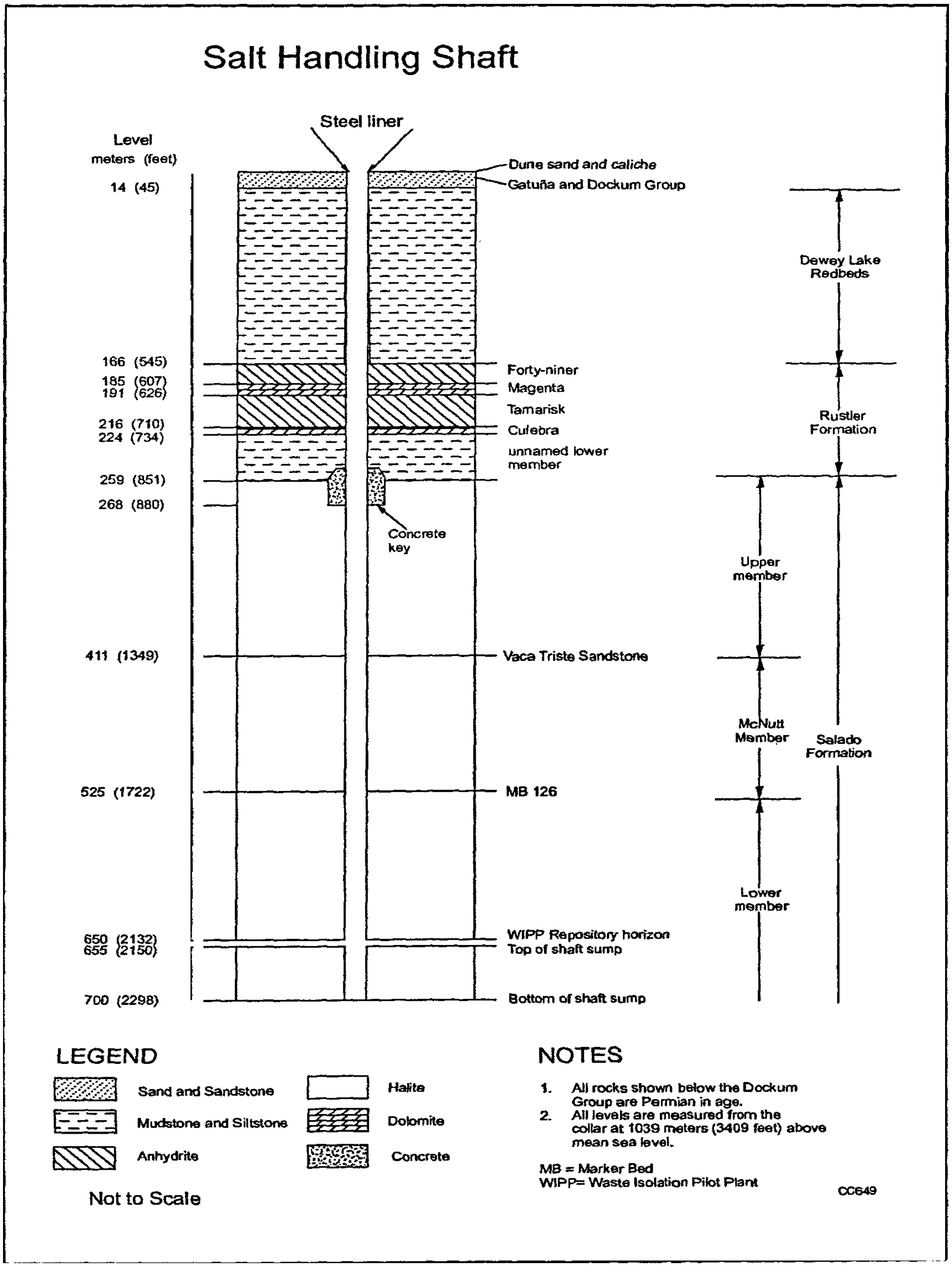

Figure 3-1 - Salt Handling Shaft Stratigraphy

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, May 5, 1999, was 1.97 cm (0.775 in.) with a calculated displacement rate of 0.103 cm/yr (0.041 in./yr). This represents an increase in displacement rate for this reporting period of greater than 50 percent compared to the displacement rate of 0.066 cm/yr (0.026 in./yr) calculated for the previous reporting period (July 1, 1997, through June 30, 1998). The present displacement rate of 0.103 cm/yr (0.041 in./yr) is not considered to be excessively high and is actually less than the extensometer anchor displacement rates observed at similar depths in the Waste Shaft and Exhaust Shaft presented below. 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 640 kilopascals (KPa) (93 pounds per square in. [psi]) at the 177-m (580-ft) level in the Forty-Niner member to over 1,400 KPa (200 psi) at the 189-m (620-ft) level in the Magenta dolomite member. The recorded pressure of 1,400 KPa (200 psi) at the Magenta dolomite represents a 50 percent increase over the recorded pressure in the same location at the end of the previous reporting period. The pressure is still within the design restraints for the shaft liner and the pressure will continue to be monitored on a regular basis.

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 -47 to -214 KPa (-7 to -31 psi). These pressures are in line with the pressures recorded during the previous reporting period.

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 functioning spot-welded strain gages located at the 261-m (856.3-ft) level reported strains of 616 and 711 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 -678 microstrain to 952 microstrain. The strains recorded from both the spot-welded strain gages and the embedment strain gages are very similar to the recorded strains from these instruments at the end of the previous reporting period.

The functioning spot-welded strain gages located at the 262.9-m (862.4-ft) level reported strains ranging from 293 microstrain to 1,787 microstrain. The 12 embedment strain gages located at the 262.9-m (862.4-ft) level reported strains ranging from -348 to

779 microstrain. Again, all strains were very similar to those reported during the previous reporting period.

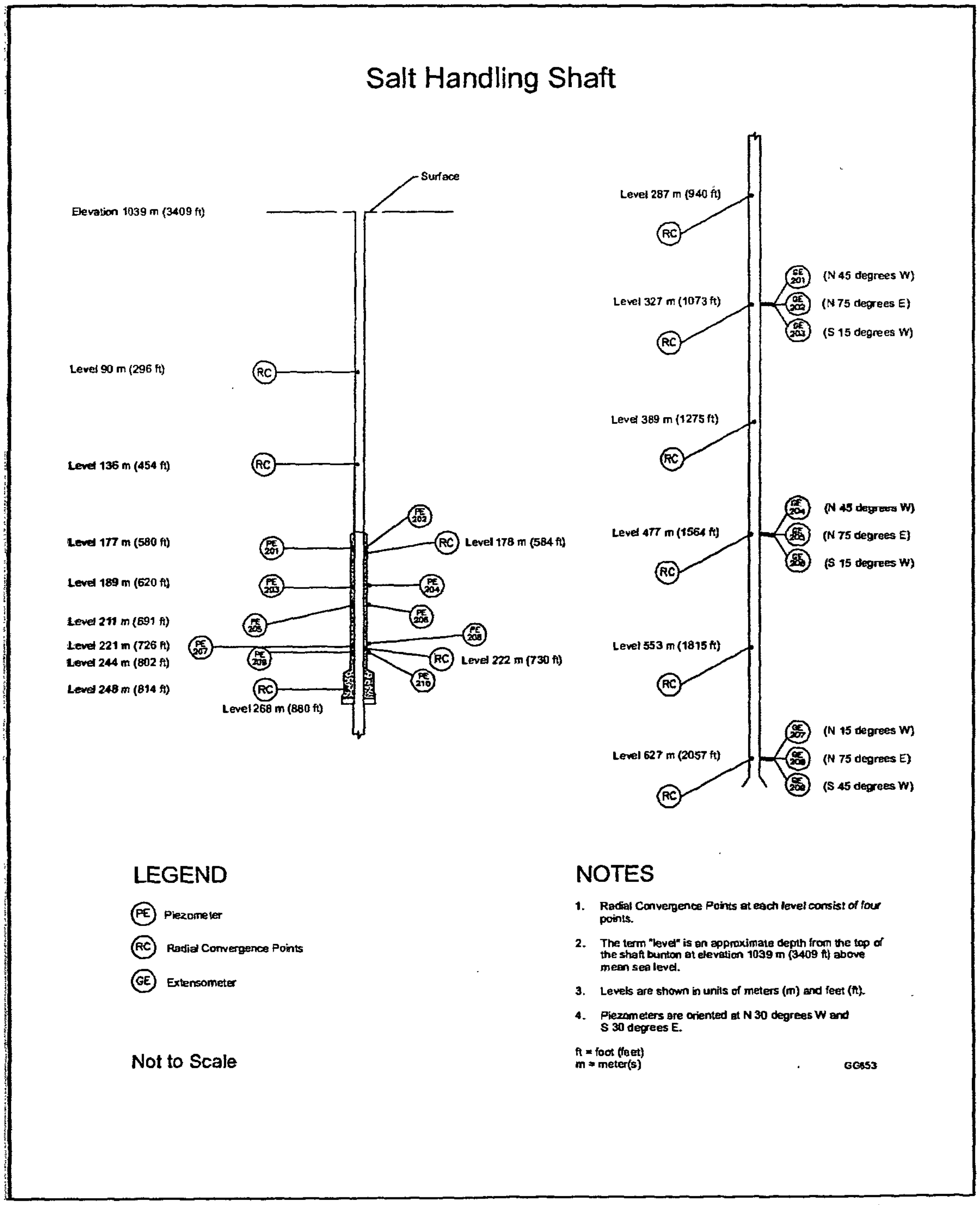

Figure 3-2 - Salt Handling Shaft Instrumentation (Without Shaft Key)

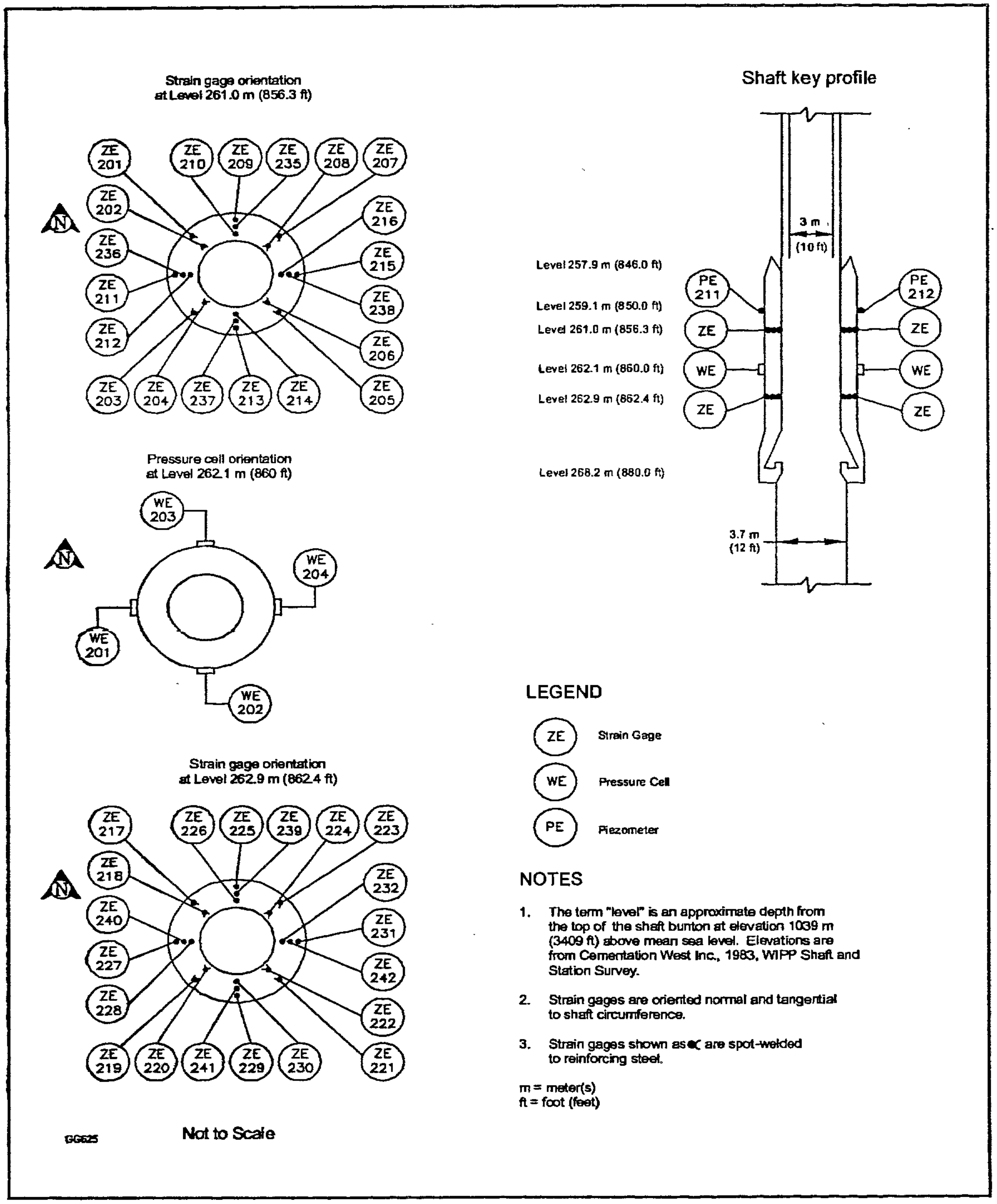

Figure 3-3 - Salt Handling Shaft Key Instrumentation

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 rock-bolts. 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 found that the Waste Shaft was in satisfactory condition. No ground control activities were required in the Waste Shaft during this reporting period.

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 6.4 m (21 ft) in height and from 4.3 m (14 ft) to 9.2 m (33 ft) in width.

5.1 Modifications to Excavation and Ground Control Activities

In preparation for extending the four major north-south access drifts toward Panel 2, E140 drift and W170 drift were enlarged along with S2180 crosscut drift. Trimming, scaling, and floor milling activities were performed as necessary in many areas throughout the WIPP underground. Table 5-1 summarizes these activities. Table 5-1 also summarizes ground control activities (e.g., rock-bolting and installing wire mesh) performed in various locations in the access drifts.

5.2 Instrumentation

Figure 5-1 shows the location of all of the geotechnical instruments within the WIPP access drifts. This section discusses instrumentation details and locations for each instrumentation type.

5.2.1 Borehole Extensometers

There were no new extensometers installed during this reporting period. 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.

5.2.2 Convergence Points

Instrumentation installed during this reporting period was limited to the installation and replacement of convergence point arrays. 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 W170 drift between S90 and S2180 to replace points that were removed when the W170 drift was trimmed in preparation as the main haulage route for mining toward Panel 2. Convergence points within the access drifts are read manually at least every two months, with more frequent monitoring in some areas. Table 5-2 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.

Table 5-1
Summary of Modifications and Ground Control Activities in the Access Drifts
July 1, 1998, Through June 30, 1999

Date Completed	Location	Work Performed
July 1998	W170 from S1000 to S1600	Installation of wire mesh anchored by rock-bolts on back and west rib
July 1998	W170 from S90 to S300	Trimming and scaling of ribs and installation of wire mesh on back and ribs
July 1998	N150 overcast – East brow	Installation of steel mats supported by rock-bolts
August 1998	S90 from W170 to Room Q entry	Trimming and scaling of south rib
August 1998	E140 from S2050 to S2200	Installation of wire mesh anchored by rock-bolts on east rib
August 1998	E140 from S700 to S1950	Floor milling
September 1998	S1950 from W170 to E140	Floor milling
October 1998	W170 from S90 to S2180	Floor milling
October 1998	W30 from S300 to S375	Installation of wire mesh anchored by rock-bolts to contain low angle fracture
October 1998	E300 at S1950 intersection	Installation of wire mesh anchored by rock-bolts in rib and brow
October 1998	E300 from S1600 to S1900	Installation of wire mesh anchored by rock-bolts
October 1998	S90 from W640 to W820	Installation of wire mesh anchored by rock-bolts on south rib
November 1998	W170 from S450 to S700	Installation of wire mesh anchored by rock-bolts on east roof
November 1998	S2180 from W30 to W170	Trimming of north rib and install wire mesh anchored by rock-bolts
November 1998	E140 from S1950 to S2185	Installation of roof support system using rock-bolts
December 1998	E140 from S120 to N150	Installation of rock-bolts in roof
January 1999	E140 from S2000 to S2180	Trimming of west rib
January 1999	W170 from S1080 to S1280	Installation of wire mesh anchored by rock-bolts
January 1999	W170 from S90 to N150	Floor milling
February 1999	N300 at W400	Trimming and scaling of north rib; Installation of wire mesh anchored by rock-bolts
March 1999	S2180 from W30 to E140	Trimming of north rib; Installation of wire mesh anchored by rock-bolts
May 1999	S2180 from W30 to E140	Trimming of south rib; Installation of wire mesh anchored by rock-bolts
May 1999	E300 at S90	Trimming of east rib
May 1999	S400 at E300 intersection	Installation of wire mesh anchored by rock-bolts at intersection miters
June 1999	W170 from N150 to N100	Trimming of east rib
June 1999	S1600 from E200 to E250	Installation of wire mesh anchored by rock-bolts on south rib
June 1999	S90 from E140 to E300	Trimming of south rib
June 1999	E300 from S90 to S200	Trimming of east rib; Rock-bolting of west rib

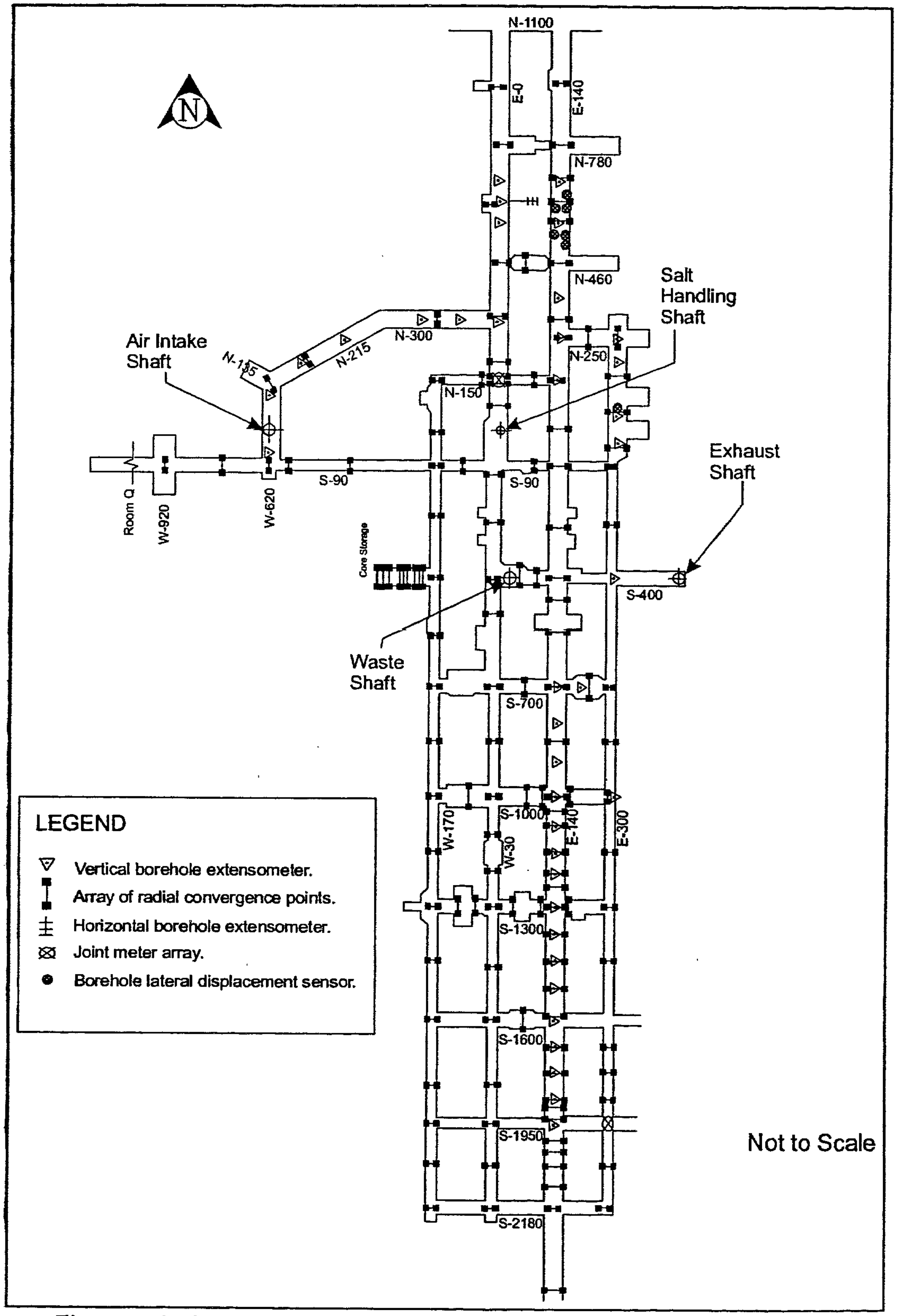

Figure 5-1 - Location of Geotechnical Instruments in the Access Drifts

Table 5-2
New and Replaced Convergence Points Installed in the Access Drifts
July 1, 1998, Through June 30, 1999

Instrument Type	N/R	Field Tag	Location	Date Installed
Convergence Points	R	N140-W50-2 (B-D)	N150 Drift at W50 (Rib-to-Rib)	9/10/1998
Convergence Points	R	N215-W500-2 (B-D)	N215 Drift at W500 (Rib-to-Rib)	9/10/1998
Convergence Points	R	S90-W770-2 (B-D)	S90 Drift at Room Q entry (Rib-to-Rib)	9/10/1998
Convergence Points	R	W170-S1600-2 (A-C)	W170 Drift at S1600 Drift (Roof-to-Floor)	10/30/1998
Convergence Points	R	W170-S1779-2 (A-C)	W170 Drift at S1779 (Roof-to-Floor)	10/30/1998
Convergence Points	R	W170-S1950-2 (A-C)	W170 Drift at S1950 Drift (Roof-to-Floor)	10/30/1998
Convergence Points	R	W170-S2060-2 (A-C)	W170 Drift at S2060 (Roof-to-Floor)	10/30/1998
Convergence Points	R	W170-S2180-2 (A-C)	W170 Drift at S2180 Drift (Roof-to-Floor)	10/30/1998
Convergence Points	R	W170-S1445-3 (A-C)	W170 Drift at S1445 (Roof-to-Floor)	10/30/1998
Convergence Points	R	W30-S700-2 (A-C)	W30 Drift at S700 Drift (Roof-to-Floor)	10/30/1998
Convergence Points	R	E140-S1456-3 (A-G)	E140 Drift at S1456 (Roof-to-Floor)	11/10/1998
Convergence Points	R	N300-W170-1 (B-D)	N300 Drift at W170 (Rib-to-Rib)	1/26/1999
Convergence Points	R	W170-S90-1 (A-C)	W170 Drift at S90 Drift (Roof-to-Floor)	1/26/1999
Convergence Points	R	W170-S850-5 (A-E, H-F)	W170 Drift at S850 (Roof-to-Floor; Rib-to-Rib)	1/26/1999
Convergence Points	R	W170-S1000-1 (A-C)	W170 Drift at S1000 Drift (Roof-to-Floor)	1/26/1999
Convergence Points	R	W170-S1150-3 (A-E, B-D)	W170 Drift at S1150 (Roof-to-Floor; Rib-to-Rib)	1/26/1999
Convergence Points	R	E0-N80-1 (A-C)	E0 Drift at N80 (Roof-to-Floor)	4/13/1999

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

5.3 Analysis of Extensometer and Convergence Point Data

Extensometer data are obtained by measuring the displacement from the instrument head (collar) to each fixed anchor of the extensometer. Convergence point data are obtained by measuring the change in distance between fixed points anchored into the rock across an opening, either from rib to rib or from roof to floor. 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 WIPP underground. Extensometer displacement rates and convergence rates indicate how an excavation is performing; rates that decrease or are relatively constant typify stable excavations, whereas increasing rates may indicate some type of developing instability.

Routinely, extensometer displacement rates and convergence rates are plotted against time, and comparisons are made between consecutive rates to identify any acceleration. Annual convergence rates are calculated by determining the difference between the final reading from this reporting period and the final reading from the previous reporting period and dividing that difference by the time between the two readings (in years). Instruments 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.

There are 38 active borehole extensometers being monitored at various locations in the access drifts. The majority of these instruments are located in the E140 drift. Where data are available annual displacement rates were calculated for each of the active extensometers and compared to the annual displacement rates from the previous reporting period. Significant percentage increases in displacement rates were observed in the E140 drift at the intersection with S700 drift, in the S700 drift at E220, and in the E0 drift at N300. Percentage increases in displacement rates at these locations were 86.5%, 22.8 percent, and 21.9 percent, respectively. Annual displacement rates at each of these three locations during this reporting period were 2.609 cm/yr (1.027 in./yr) at E140/S700, 1.416 cm/yr (0.557 in./yr) at S700/E220, and 1.727 cm/yr (0.680 in./yr) at E0/N300.

Where possible, annual closure rates were calculated from convergence point array data from the access drifts. A complete tabulation of these convergence point data and calculated closure rates are presented in the supporting data document for this report.[3] Locations with increases in annual vertical and horizontal closure rates of greater than 10 percent are listed in Table 5-3 and Table 5-4.

Further analysis of these accelerations has shown many of them to be relatively insignificant. Others, such as in W170 drift, had the rates reduce back to previous reporting period rates after the drift was trimmed. This short-term increase in rate is

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[3]Instrumentation data and data plots are available in "Geotechnical Analysis Report for July 1998-June 1999 Supporting Data." This document is available upon request from Westinghouse, Waste Isolation Division. Refer to Foreword and Acknowledgments for details and address.

likely due to the large scale trimming being performed in the W170 drift. An analysis using the running median of the convergence rate was used on the locations in Tables 5-3 and 5-4 where ground control measures (trimming or rock-bolting) were not instituted during this reporting period. None of the convergence point pairs showed a trend of increasing convergence rates over the long-term median convergence rate.

Some of the increases in convergence rate reported in Tables 5-3 and 5-4 may be the result of inconsistencies in application of the rate calculation method. The annual vertical convergence rate for this reporting period at E140-S400 was calculated on only four months of data (June 1, 1998, through October 5, 1998 -- the last reading for this instrument). The four month period on which the rate is calculated is during the warmer summer months when rates have been observed to increase (see Section 5.4 below). Likewise, the increase in rate at E0-N80 after trimming is based on a closure rate calculated from only one reading, taken in June 1999 after the instrument was replaced on April 13, 1999.

5.4 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.

Table 5-3
Increases in Annual Vertical Convergence Rates of Greater than 10 Percent Access Drifts

Location	Date Excavated	Convergence Rate 6/97 to 6/98 cm/yr (in./yr)	Convergence Rate 6/98 to 6/99 cm/yr (in./yr)	Increase in Convergence Rate[a] % increase	Comments
E140-S400 (A-C)	11/18/1982	4.62 (1.82)	6.07 (2.39)	31.6%	Instrument last read 10/5/1998
E140-S1150 (B-F)	12/13/1982	4.16 (1.64)	4.61 (1.81)	10.8%	
E140-S1378 (A-E)	12/17/1982	3.93 (1.55)	4.46 (1.76)	13.5%	
E140-S1378 (H-F)	12/17/1982	4.93 (1.94)	5.47 (2.15)	11.0%	
E140-S1456 (A-G)	12/17/1982	4.64 (1.83)	6.27 (2.47)	35.1%	Rate after trimming has reduced to 4.82 cm/yr
E140-S1456 (B-F)	12/17/1982	4.86 (1.91)	5.69 (2.24)	17.1%	
E140-S1534 (A-E)	12/19/1982	5.27 (2.07)	6.76 (2.66)	28.3%	
E140-S1534 (H-F)	12/19/1982	4.91 (1.93)	5.44 (2.14)	10.8%	
E140-S1917 (A-C)	12/23/1982	3.93 (1.55)	5.16 (2.03)	31.3%	Present rate of 5.16 cm/yr is less than rate during 1996 and 1997 of 6.20 cm/yr
E0-N80 (A-C)	10/15/1982	3.97 (1.56)	4.40 (1.73)	10.9%	Rate after trimming has increased to 4.71 cm/yr
W30-S700 (A-C)	8/8/1984	2.72 (1.07)	4.12 (1.62)	51.5%	Rate after trimming has reduced to 2.36 cm/yr
W30-S2180 (A-C)	7/18/1988	2.65 (1.04)	2.95 (1.16)	11.6%	
W170-S90 (A-C)	8/4/1984	1.63 (0.64)	2.96 (1.17)	81.9%	Rate after trimming has reduced to 1.93 cm/yr
W170-S1000 (A-C)	8/19/1984	1.82 (0.72)	2.32 (0.91)	26.9%	Rate after trimming has reduced to 1.89 cm/yr
W170-S1150 (A-E)	8/20/1984	1.66 (0.65)	2.01 (0.79)	21.1%	Rate after trimming has reduced to 0.75 cm/yr
W170-S1600 (A-C)	9/3/1984	2.01 (0.79)	2.29 (0.90)	14.0%	Rate after trimming has reduced to 2.02 cm/yr
W170-S2180 (A-C)	8/2/1988	2.07 (0.81)	2.46 (0.97)	19.3%	Rate after trimming has reduced to 2.19 cm/yr
S90-W100 (A-C)	7/1/1985	1.35 (0.53)	1.50 (0.59)	11.2%	

[a] Increase in convergence rate is calculated from the difference between the 1997-1998 rate and the 1998-1999 rate.

cm/yr = centimeter(s) per year.

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

Table 5-4
Increases in Annual Horizontal Convergence Rates of Greater than 10 Percent
Access Drifts

Location	Date Excavated	Convergence Rate 6/97 to 6/98 cm/yr (in./yr)	Convergence Rate 6/98 to 6/99 cm/yr (in./yr)	Increase in Convergence Rate[a] % increase	Comments
E300-S1150 (C-G)	7/23/1984	1.50 (0.59)	1.68 (0.66)	11.8%	
W30-S1775 (B-D)	2/14/1986	1.63 (0.64)	1.81 (0.71)	10.8%	
N300-W170 (B-D)	10/4/1988	2.90 (1.14)	3.28 (1.29)	13.2%	Rate after trimming has reduced to 3.17 cm/yr
N215-W500 (B-D)	12/31/1987	2.36 (0.93)	3.55 (1.40)	50.8%	Rate after trimming has reduced to 2.37 cm/yr
S90-W100 (B-D)	7/1/1985	1.35 (0.53)	1.61 (0.63)	19.2%	

[a] Increase in convergence rate is calculated from the difference between the 1997-1998 rate and the 1998-1999 rate.
cm/yr = centimeter(s) per year
in./yr = inch(es) per year

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 Entry into Deactivated Area

In March 1999, members of the Geotechnical Engineering Section and Underground Operations made an entry into the deactivated Northern Experimental Area. The purpose for the entry was to repair/replace a data logger located in SPDV Room 4 that had failed in October 1998. Entry was made by penetrating the Omega block walls in the E0 and E140 drifts at N820. Ventilation was established prior to personnel entry. The data logger was replaced without incident and the replacement is working properly.

6.3 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.

6.3.1 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 at the end of this reporting period and the calculated displacement rate for this and the previous reporting period for each of these extensometers.

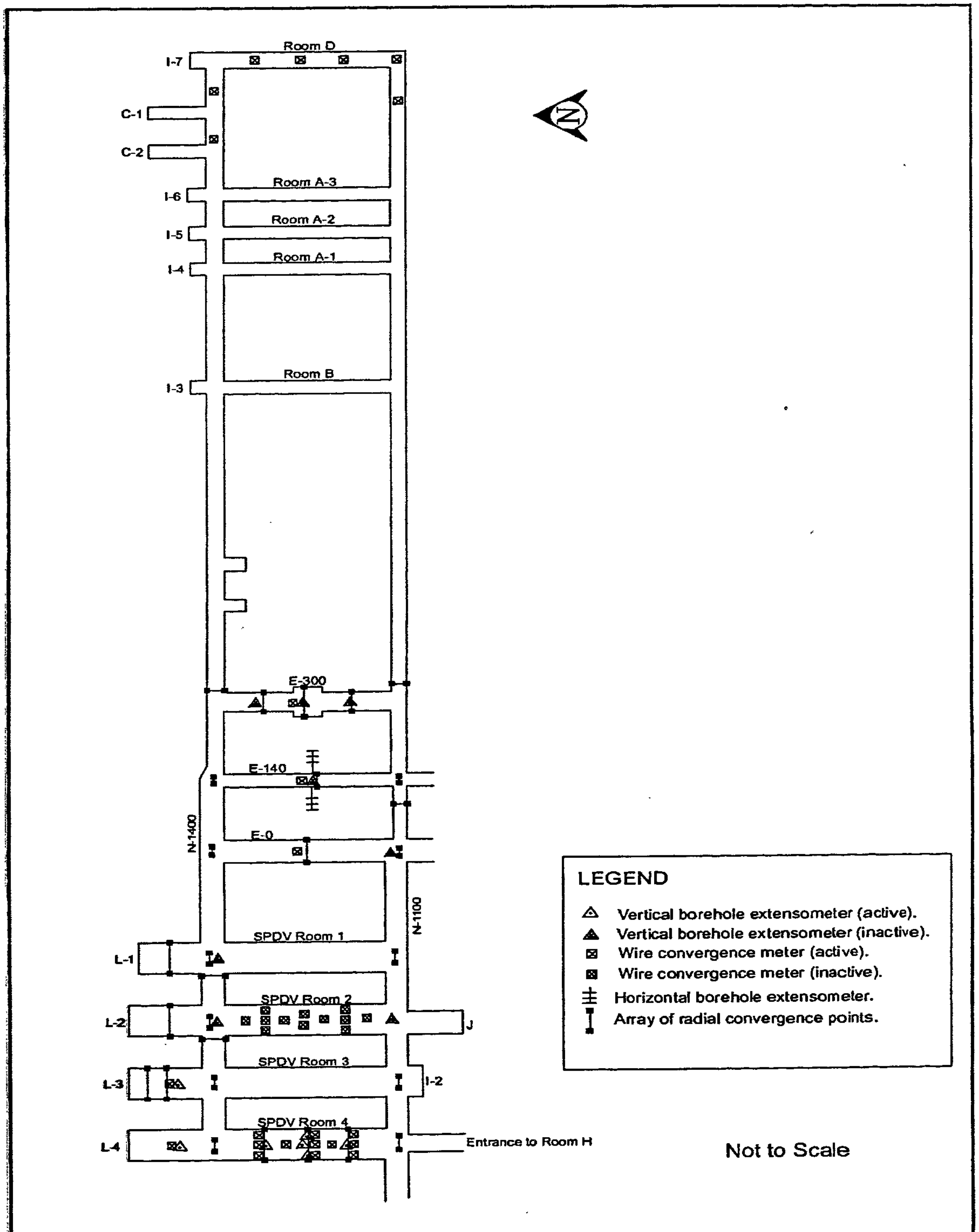

Figure 6-1 - Location of Active and Inactive Geotechnical Instruments in the Northern Experimental Area

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 (Panel 1) during the reporting period of July 1998 through June 1999. Routine maintenance and ground control activities in the form of trimming, scaling, rock-bolt replacement, and installing wire mesh was performed on ribs, floor, and roof throughout Panel 1. 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, 1998, Through June 30, 1999

Date Completed	Location	Work Performed
September 1998	Room 5, Panel 1	Installation of welded wire mesh panels and cable slings anchored by rock-bolts at center of room
September 1998	S1600 drift at Room 4	Installation of rock-bolts for roof/rib support in roof and north rib
December 1998	Room 3, Panel 1	Installation of wire mesh anchored by rock-bolts
December 1998	S1600 between Room 6 and 7	Scaling of the ribs
January 1999	Room 5 at S1950 Drift Intersection	Installation of wire mesh anchored by rock-bolts at southeast miter of intersection
January 1999	Room 6 at S1600 Drift Intersection	Installation of wire mesh anchored by rock-bolts at intersection
March 1999	Room 2, Panel 1	Installation of wire mesh anchored by rock-bolts on portion of west rib
March 1999	Room 3, Panel 1	Installation of wire mesh anchored by rock-bolts on portion of west rib
May 1999	S1950 Drift	Floor trimming from Panel 1 entrance to Room 7
May 1999	Room 2, Panel 1	Trimming and installation of wire mesh anchored by rock-bolts on portion of west rib

7.2 Instrumentation

No extensometers were installed or replaced in Panel 1 during this reporting period. Thirteen convergence point pairs were replaced in the S1950 drift entry (between E300 and Room 1) during this reporting period. Several of these pairs were replaced more than once during the period as additional trimming of the floor was performed. Table 7-2 lists the convergence point pairs replaced. Figure 7-1 shows the location of the various types of geotechnical instruments in Panel 1 of the Waste Disposal Area.

The 286 rock-bolt load cells of the yielding roof support system in Room 1 are monitored regularly and are detensioned as needed. As the roof beam expands the tension in the rock-bolts increases. Scheduled detensioning of the rock-bolts is performed approximately every five weeks to maintain the load supported by the rock-bolt 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 rock-bolts are typically maintained between approximately 22 and 89 kilonewtons (5,000 and 20,000 lb). However, seventeen of these rock-bolts have reached their maximum adjustment point and the load on these bolts can no longer be kept below the 89-kilonewton (20,000-lb) level. Loads on these bolts currently range from 116 kilonewtons (26,000 lb) to 242 kilonewtons (54,400 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 [Waste Isolation Division], 1999) provides information on the status of the roof support system.

Table 7-2
Replaced Instrumentation in the Waste Disposal Area
July 1, 1998, Through June 30, 1999

Instrument Type	Field Tag	Location	Date Installed
Convergence Point Pair	S1950-E281-3 (A-C)	S1950 Drift Entrance at E281	7/21/1998
Convergence Point Pair	S1950-E284-3 (A-C)	S1950 Drift Entrance at E284	7/21/1998
Convergence Point Pair	S1950-E311-3 (A-C)	S1950 Drift Entrance at E311	7/21/1998
Convergence Point Pair	S1950-E311-4 (A-C)	S1950 Drift Entrance at E311	9/10/1998
Convergence Point Pair	S1950-E332-3 (A-C)	S1950 Drift Entrance at E332	7/21/1998
Convergence Point Pair	S1950-E332-4 (A-C)	S1950 Drift Entrance at E332	9/10/1998
Convergence Point Pair	S1950-E357-5 (A-C)	S1950 Drift Entrance at E357	7/21/1998
Convergence Point Pair	S1950-E357-6 (A-C)	S1950 Drift Entrance at E357	9/10/1998
Convergence Point Pair	S1950-E357-7 (A-C)	S1950 Drift Entrance at E357	4/13/1999
Convergence Point Pair	S1950-E382-4 (A-C)	S1950 Drift Entrance at E382	7/21/1998
Convergence Point Pair	S1950-E382-5 (A-C)	S1950 Drift Entrance at E382	9/10/1998
Convergence Point Pairs	S1950-E407-3 (A-G, B-F, L-H)	S1950 Drift Entrance at E407	7/21/1998
Convergence Point Pair	S1950-E407-4 (A-G)	S1950 Drift Entrance at E407	4/13/1999
Convergence Point Pair	S1950-E432-3 (A-C)	S1950 Drift Entrance at E432	7/21/1998
Convergence Point Pair	S1950-E457-3 (A-C)	S1950 Drift Entrance at E457	7/21/1998
Convergence Point Pair	S1950-E482-6 (A-C)	S1950 Drift Entrance at E482	7/21/1998
Convergence Point Pair	S1950-E503-5 (A-C)	S1950 Drift Entrance at E503	7/21/1998

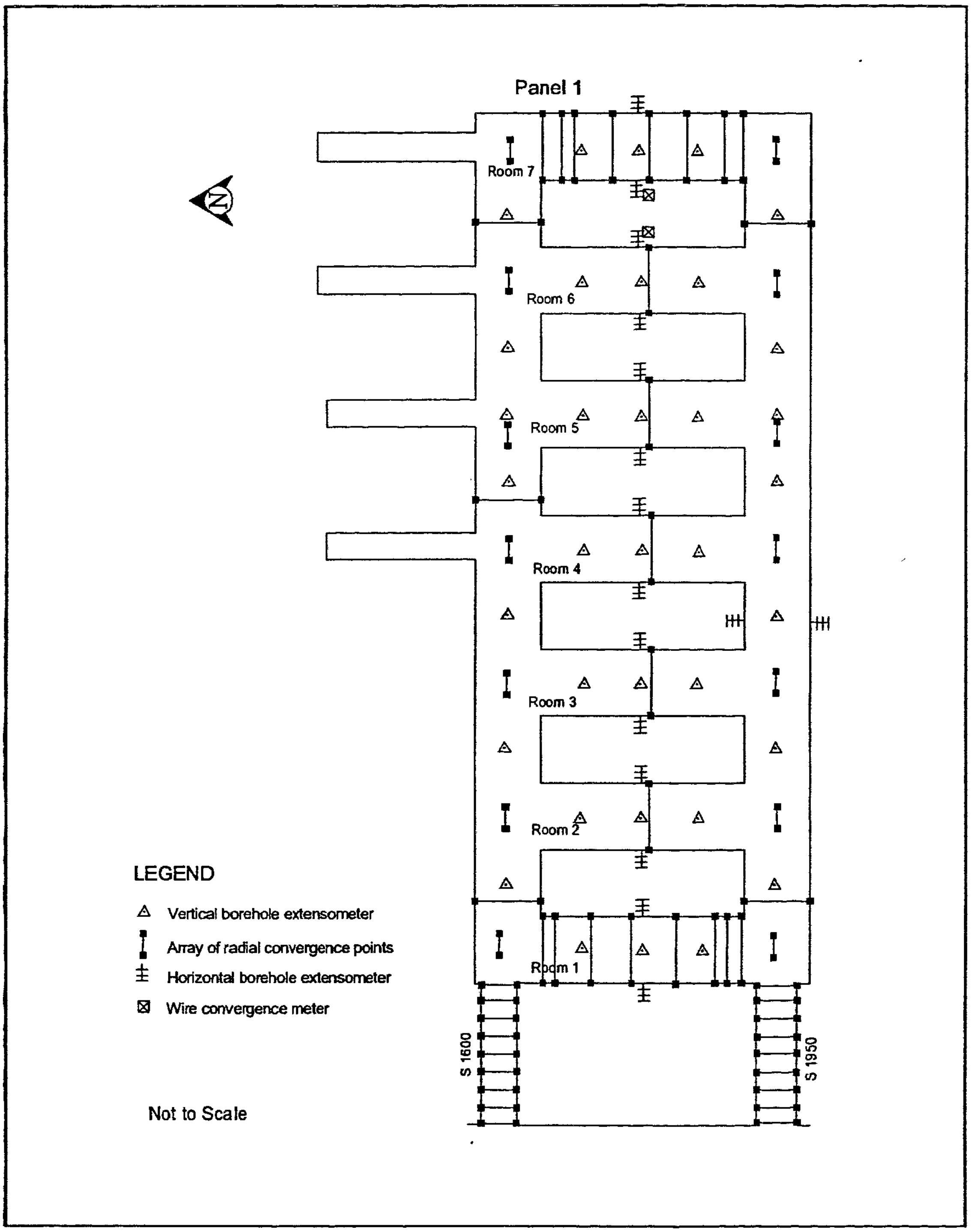

Figure 7-1 - Location of Geotechnical Instruments in the Waste Disposal Area

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 this and the previous two 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 have 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 have also remained constant or decreased during the current reporting period relative to the previous period.

Fracturing within the immediate roof beam contributes to high convergence rates seen in some areas of Panel 1, especially portions of Room 1. 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, 1999). Vertical convergence rates within Room 1, Panel 1 have decreased during this reporting period at 18 of the 22 locations monitored. The convergence point pair located at the east quarter point at S1884 in Room 1, Panel 1 did exhibit a 14.3 percent increase in convergence rate during this reporting period and does now have one of the highest convergence rates in Room 1 at 7.92 cm/yr (3.12 in./yr). This area will continue to be monitored closely. If conditions in Room 1 adversely change, the ground support system will be upgraded or adjusted as necessary, or the room will be abandoned.

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

Location		Field Tag	1996-1997 Convergence Rate cm/yr (in./yr)	1997-1998 Convergence Rate cm/yr (in./yr)	1998-1999 Convergence Rate cm/yr (in./yr)
Room 1	Centerline	E520-S1802-6 A-E	7.89 (3.11)	6.79 (2.67)	6.20 (2.44)
Room 2	Centerline	E660-S1775-5 A-C	5.72 (2.25)	5.64 (2.22)	5.85 (2.30)
Room 3	Centerline	E790-S1775-3 A-C	7.76 (3.05)	6.32 (2.49)	5.60 (2.20)
Room 4	East of centerline	E920-S1775-5 A-F	5.88 (2.32)	5.40 (2.13)	5.29 (2.08)
Room 4	West of centerline	E920-S1775-4 B-E	4.42 (1.74)	4.14 (1.63)	3.90 (1.54)
Room 5	East of centerline	E1050-S1775-4 A-F	5.94 (2.34)	5.52 (2.17)	5.38 (2.12)
Room 5	West of centerline	E1050-S1775-4 B-E	5.99 (2.36)	5.32 (2.10)	5.50 (2.17)
Room 6	East of centerline	E1190-S1775-4 A-F	6.00 (2.36)	5.50 (2.17)	5.27 (2.07)
Room 6	West of centerline	E1190-S1775-3 B-E	5.89 (2.32)	5.41 (2.13)	5.08 (2.00)
Room 7	East of centerline[a]	E1320-S1775-3 A-F	5.80 (2.28)	No Data	No Data
Room 7	East of centerline[a]	E1320-S1775 B-D	No Data	5.89 (2.32)	5.44 (2.14)
Room 7	West of centerline[a]	E1320-S1775-4 B-E	5.79 (2.28)	No Data	No Data
Room 7	West of centerline[a]	E1320-S1775 H-F	No Data	6.68 (2.63)	6.02 (2.37)
Room 7	Centerline[a]	E1320-S1775 A-E	No Data	6.57 (2.59)	6.18 (2.43)

[a] Convergence point pairs for Room 7 center were replaced in June 1997. New convergence point pairs are located at room centerline and at east and west quarter points.
cm/yr = centimeter(s) per year
in./yr = inch(es) per year

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

Location		Field Tag	1996-1997 Convergence Rate cm/yr (in./yr)	1997-1998 Convergence Rate cm/yr (in./yr)	1998-1999 Convergence Rate cm/yr (in./yr)
Room 1	Rib center	E520-S1802-3 C-G	3.49 (1.37)	3.35 (1.32)	3.14 (1.24)
Room 2	Rib center	E660-S1775-5 B-D	3.06 (1.21)	3.19 (1.26)	3.19 (1.26)
Room 3	Rib center	E790-S1775-5 B-D	4.29 (1.69)	4.33 (1.70)	4.01 (1.58)
Room 4	Above rib center	E920-S1775-5 C-H	3.85 (1.52)	3.76 (1.48)	3.66 (1.44)
Room 4	Below rib center	E920-S1775-5 D-G	3.70 (1.46)	3.72 (1.47)	3.39 (1.33)
Room 5	Above rib center	E1050-S1775-5 C-H	3.68 (1.45)	3.75 (1.48)	3.73 (1.47)
Room 5	Below rib center	E1050-S1775-5 D-G	3.72 (1.46)	3.71 (1.46)	3.64 (1.43)
Room 6	Above rib center	E1190-S1775-4 C-H	3.17 (1.25)	3.16 (1.24)	3.06 (1.20)
Room 6	Below rib center	E1190-S1775-4 D-G	3.24 (1.27)	3.22 (1.27)	3.03 (1.19)
Room 7	Above rib center[a]	E1320-S1775-5 C-H	3.14 (1.24)	No Data	No Data
Room 7	Below rib center[a]	E1320-S1775-5 D-G	3.17 (1.25)	No Data	No Data
Room 7	Rib center[a]	E1320-S1775 C-G	No Data	3.29 (1.30)	3.08 (1.21)

[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

7.4 Analysis of Extensometer and Convergence Point Data

As discussed in Section 5.3, extensometer data are obtained by measuring the displacement from the instrument head (collar) to each fixed anchor of the extensometer. Convergence point data are obtained by measuring the change in distance between fixed points anchored into the rock across an opening, either from rib to rib or from roof to floor. Extensometer displacement rates and convergence rates are plotted against time, and comparisons are made between consecutive rates 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.

There are 37 active extensometers installed in the roofs and ribs of Panel 1 of the Waste Disposal Area with most being located in the disposal rooms. Two of these extensometers have shown increases in calculated displacement rates of greater than 10 percent during this reporting period. Both instruments are located horizontally in ribs and have displacement rate increases of 15.2 percent in the east rib of Room 2 and 20.6 percent in the west rib of Room 7.

Where possible, annual closure rates were calculated from convergence point array data from the access drifts. The convergence rate at most points in Panel 1 have reduced during this reporting period relative to the previous reporting period. Three pairs of convergence points were found to have increases in annual vertical or horizontal convergence rates of greater than 10 percent. An increase of 14.4 percent was calculated for one horizontal chord in S1950 drift at E407 in the Panel 1 entry. Other horizontal chords also located at E407 showed smaller increases in rate of 5.0 and 6.9 percent. The floor in this area of S1950 drift was trimmed during this reporting period and may have contributed to the increase in convergence rate. The second location is also in S1950 at E523 with an increase in vertical convergence rate of 12.9 percent. The third location is in Room 1 at S1884 and is discussed above in Section 7.3. All areas will continue to be monitored closely.

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 1998 through June 1999.

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. Extensometer 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 has reduced in volume during this reporting period. 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. W170 drift was trimmed/enlarged to function as a salt haulage route for the future excavation of Panel 2.
	"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 rock-bolting, 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. This annual report acts to provide a summary and analysis of the geomechanical data. 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

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 rock-bolts. 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 and rib trimming in W170 drift and S2180 drift (trimmed in preparation for being used as salt haulage route during the excavation of Panel 2 and associated access drifts), rib, roof, and floor scaling and trimming in various locations, and rock-bolting and wire mesh installation as needed. Supplemental ground support systems consisting of cable slings and welded wire mesh were installed in the center 46 m (150 ft) of Room 5, Panel 1.

New convergence point pairs were installed in the entrance to Panel 1 in S1950 drift, in the W170 drift, and in various locations throughout the repository to replace mined out instruments. Entry was made into the deactivated Northern Experimental Area to replace a malfunctioning data logger located in SPDV Room 4. Remotely read instrumentation located in this area is once again providing data for analysis.

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. The ground condition in the Waste Disposal Area and associated transuranic waste haulage routes in the WIPP underground has remained stable during this reporting period. Most of the calculated annual convergence rates for Panel 1 decreased during this reporting period relative to the rates from the previous two reporting periods.

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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Effective Date: 03/16/98

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

WASTE ISOLATION PILOT PLANT WIPP

GEB_M2001-D

TABLE OF CONTENTS

1.0 INTRODUCTION . . . 1
1.1 Background . . . 1
1.2 Geosciences Program . . . 2
1.3 Geomechanical Monitoring Program . . . 2
1.4 Rock Mechanics Program . . . 2
1.5 Ground Control Program . . . 2

2.0 ADMINISTRATION . . . 3
2.1 Organization . . . 3
2.2 Responsibilities . . . 3
2.3 Training and Qualifications . . . 3

3.0 TECHNICAL PROGRAM DESCRIPTION . . . 3
3.1 Geosciences Program . . . 3
3.1.1 Background . . . 3
3.1.2 Purpose . . . 4
3.1.3 Scope . . . 4
3.1.4 Methods . . . 4
3.2 Geomechanical Monitoring Program . . . 5
3.2.1 Background . . . 6
3.2.2 Purpose . . . 6
3.2.3 Scope . . . 6
3.2.4 Methods . . . 7
3.3 Rock Mechanics Program . . . 10
3.3.1 Background . . . 10
3.3.2 Purpose . . . 10
3.3.3 Scope . . . 10
3.3.4 Methods . . . 11
3.4 Ground Control Program . . . 12
3.4.1 Background . . . 13
3.4.2 Purpose . . . 13
3.4.3 Scope . . . 14
3.4.4 Methods . . . 14

4.0 QUALITY ASSURANCE . . . 15
4.1 Design Control . . . 15
4.2 Procurement . . . 15
4.3 Instructions, Procedures and Drawings . . . 15
4.4 Document Control . . . 16
4.5 Control of Purchased Material, Equipment, and Services . . . 16
4.6 Identification and Control of Items . . . 16
4.7 Test Control . . . 16

4.8 Software Requirements 17
4.9 Control of Monitoring and Data Collection Equipment 18
4.10 Handling, Storage, and Shipping 18
4.11 Control of Nonconforming Conditions/Items 18
4.12 Corrective Actions 18
4.13 Records Management 19
4.14 Audits and Independent Assessments 19
4.15 Data Reduction and Verification 19

5.0 REFERENCES 19

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.

Routine Activities

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.

<u>Routine Activities</u>

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.

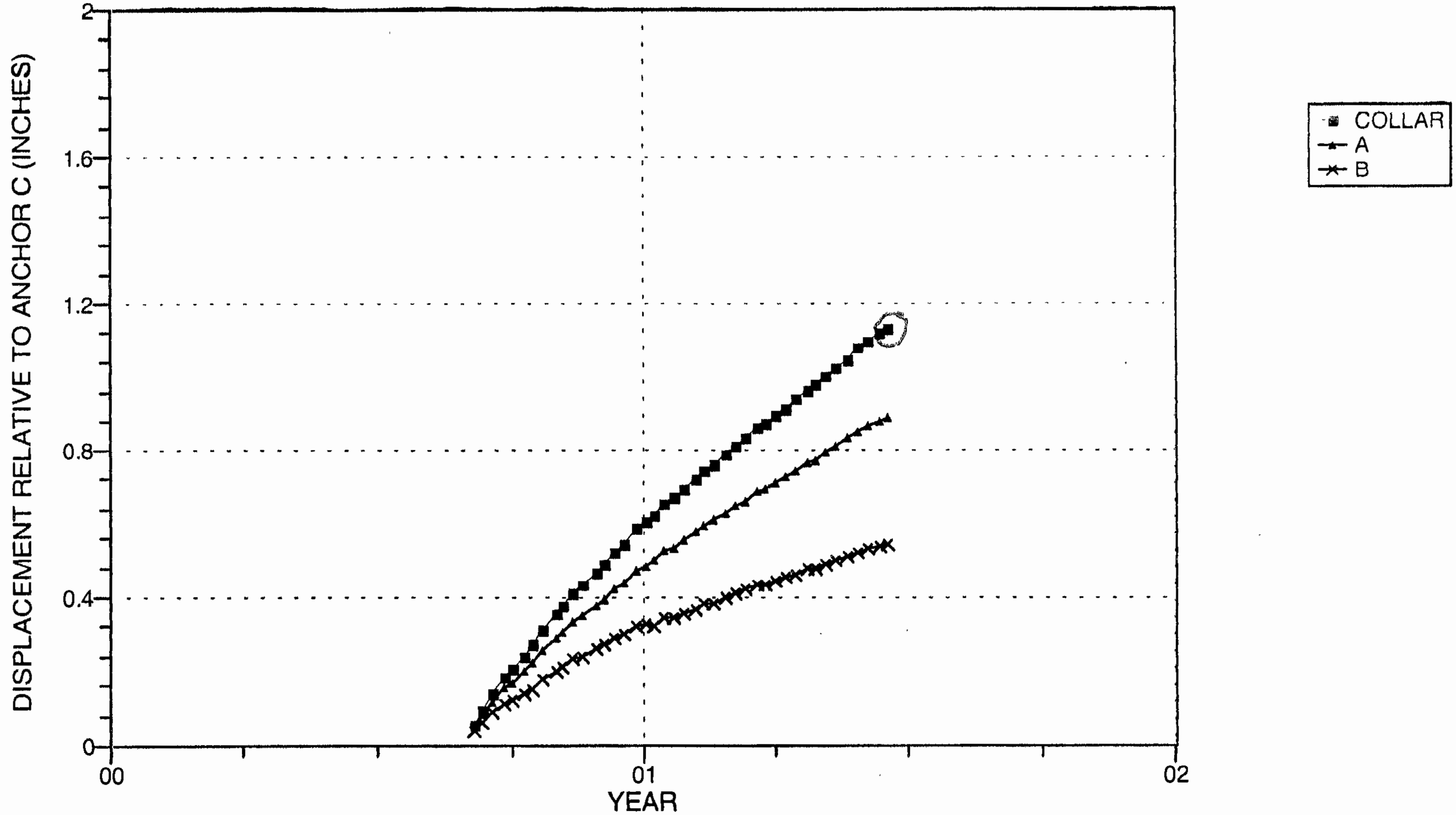
4.15 Data Reduction and Verification

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

EXTENSOMETER 51X-GE-00344
PANEL 2 ROOM 4 - CENTER ROOF



NOTES:
1. INSTALLED:

P-1002W-980

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51X-GE-00346	WEX	3.552	05:+3.5521	82011	6/18/01	07:05
51X-GE-00346	WEX	3.396	06:+3.3956	82012	6/18/01	07:05
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51X-GE-00344	WEX	4.142	18:+4.1423	82024	6/18/01	07:05
51X-GE-00343	WEX	3.119	19:+3.1193	82025	6/18/01	07:05
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51X-GE-00341	WEX	3.846	33:+3.8465	82003	6/18/01	07:05

Number of Records: 33

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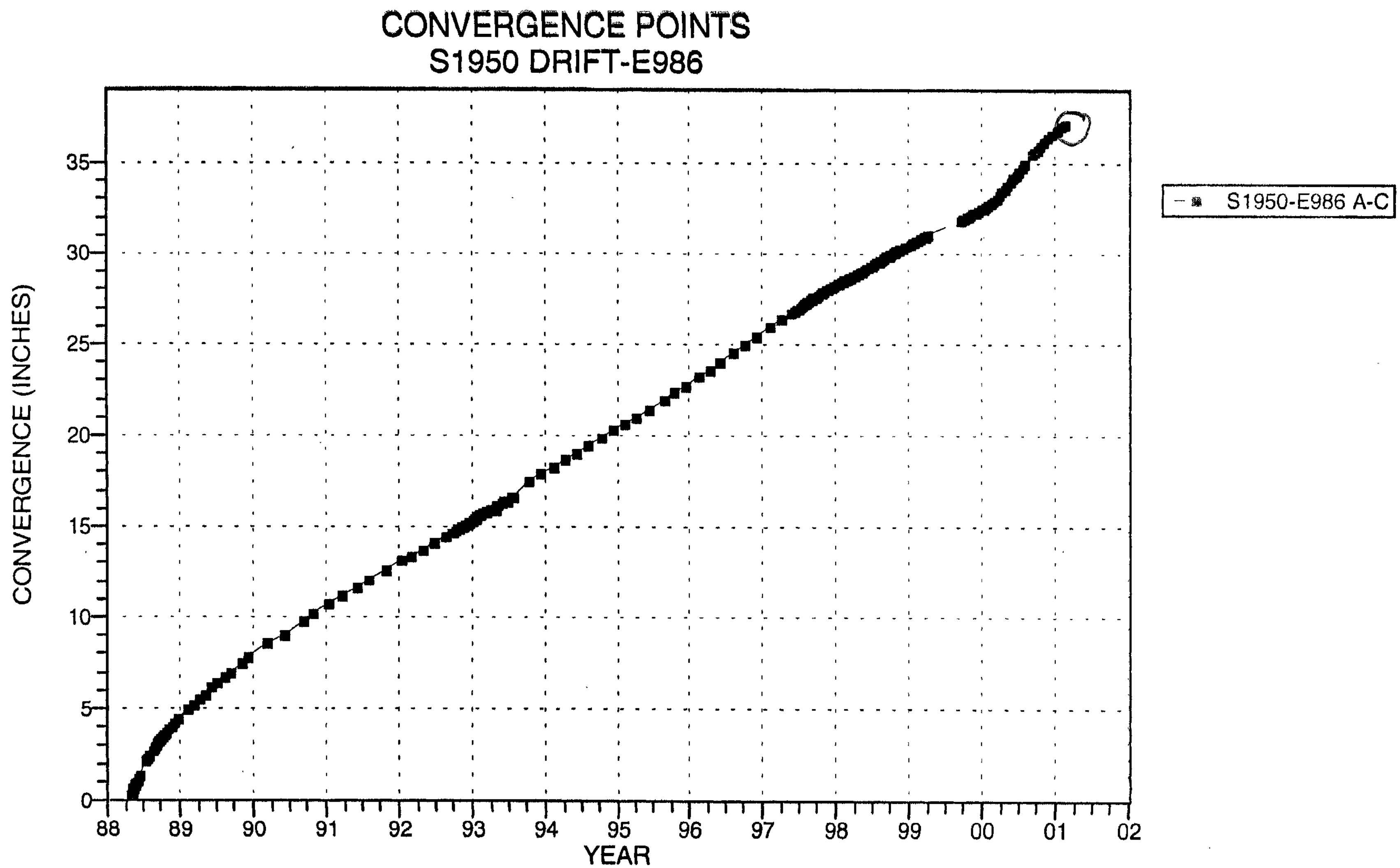
Edited by ____________________ Date __________

X Checkprint

0 Errors Found Checked by [signature] Date 6/15/0



NOTES:
1. EXCAVATION DATE: JULY 3, 1986.

GIS FIELD DATA SHEET

DATE 02'19'01 TIME 8:04 READINGS BY Batchelder/Barrios

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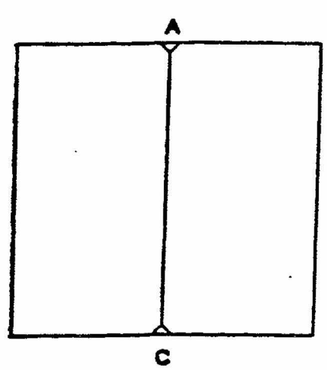
SKETCH OF INSTALLATION



VIEW LOOKING WEST

STATION S1950-E986

INSTRUMENT TYPE CVPT

READING DEVICE SINCO

SERIAL NUMBER 11493

CHECK DATE 04/10/01

COMMENTS Check for cracks, erosion, salt build-up, damage, corrosion, loose or missing parts, malfunctions and structural deterioration.

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18346	9/18/00	10:39	141.506	3.863
18346	10/2/00	9:54	141.351	4.018
18346	10/16/00	9:17	141.176	4.193
18346	11/1/00	9:00	140.986	4.383
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CVPTDATA.DBF

Effective Date: 11/1799

WP 02-1
Revision 5

WIPP Groundwater Monitoring Program Plan

Cognizant Section: Environmental Monitoring

Approved By: W. R. White

WASTE ISOLATION PILOT PLANT
WIPP

CCB_M2001-C

Table of Contents

1.0 INTRODUCTION 1

2.0 REFERENCES 3

3.0 GEOLOGIC AND HYDROLOGIC CHARACTERISTICS 6
3.1 Geology 6
3.2 Groundwater Hydrology 8
3.2.1 The Castile 8
3.2.2 The Salado 8
3.2.3 The Rustler 8

4.0 GENERAL REGULATORY REQUIREMENTS 13

5.0 WIPP GROUNDWATER DETECTION MONITORING PROGRAM (DMP) OVERVIEW 15
5.1 Scope 15
5.2 Current WIPP DMP 16
5.2.1 DMP Well Construction Specification 18
5.3 Well Plugging and Abandonment (P&A) 20

6.0 MONITORING PROGRAM DESCRIPTION 21
6.1 Monitoring Frequency 22
6.2 Analytical Parameters 23
6.3 Groundwater Surface Elevation Measurement, Sample Collection and Laboratory Analysis 23
6.3.1 Groundwater Surface Elevation Monitoring Methodology . . . 23
6.3.2 Field Methods and Data Collection Requirements 26
6.3.3 Groundwater Surface Elevation Records and Document Control 26
6.4 Groundwater Sampling 27
6.4.1 Groundwater Pumping and Sampling Systems 27
6.4.2 Pressure Monitoring Systems 28
6.4.3 Sampling Overview 28
6.4.4 Sample Preservation, Tracking, Packaging, and Transportation 32
6.4.5 Sample Documentation and Custody 33
6.5 Laboratory Analysis 34

7.0 CALIBRATION 35
7.1 Sampling Equipment Calibration Requirements 35
7.2 Groundwater Surface Elevation Monitoring Equipment Calibration Requirements 35

8.0 STATISTICAL ANALYSIS OF LABORATORY DATA 36
8.1 Temporal and Spatial Analysis 36
8.2 Distributions and Descriptive Statistics 37
8.3 Data Anomalies 38

9.0 COMPARISONS AND REPORTING 38
9.1 Reporting 39
9.1.1 Laboratory Data Reports 39
9.1.2 Statistical Analysis and Reporting of Results 40
9.1.3 Annual Site Environmental Report 40

10.0 RECORDS MANAGEMENT 40

11.0 PROJECT ORGANIZATION AND RESPONSIBILITIES 41
11.1 Environmental Monitoring Manager 41
11.2 Team Leader 42
11.3 Field Team 42
11.4 Safety Manager 42
11.5 Analytical Laboratory Manager 42
11.6 Quality Assurance (QA) Manager 43

12.0 QUALITY ASSURANCE REQUIREMENTS 43
12.1 QA Program Review 43
12.1.1 Data Quality Objectives (DQOs) 43
12.2 Design Control 47
12.3 Instructions, Procedures, and Drawings 47
12.4 Document Control 47
12.5 Control of Work Processes 47
12.6 Inspection and Surveillance 48
12.7 Control of Monitoring and Data Collection Equipment 48
12.8 Control of Nonconforming Conditions 48
12.9 Corrective Action 48
12.10 Quality Assurance Records 49

TABLE 1	HYDROLOGICAL PARAMETERS FOR ROCK UNITS ABOVE THE SALADO AT WIPP	50
TABLE 2	WIPP GROUNDWATER DETECTION MONITORING PROGRAM SAMPLE COLLECTION AND GROUNDWATER SURFACE ELEVATION MEASUREMENT FREQUENCY	52
TABLE 3	ANALYTICAL PARAMETER LIST FOR THE WIPP GMP	53
TABLE 4	TYPICAL PARAMETER AND SAMPLE VOLUME REQUIREMENTS	54
TABLE 5	RCRA PERMIT STIPULATIONS REQUIRING ACTIONS, REPORTING, OR NOTIFICATIONS	55
FIGURE 1	HIERARCHY OF DOCUMENTS GOVERNING THE GMP	58
FIGURE 2	WIPP FACILITY LOCATION	59
FIGURE 3	SITE GEOLOGIC COLUMN	60
FIGURE 4	WIPP DMW CONFIGURATION WITH POTENTIOMETRIC SURFACES IN RELATIONSHIP TO THE WIPP SITE	61
FIGURE 5	WLMP PROGRAM WELLS	62
FIGURE 6	AS-BUILT CONFIGURATION OF WELL WQSP-1	63
FIGURE 7	AS-BUILT CONFIGURATION OF WELL WQSP-2	64
FIGURE 8	AS-BUILT CONFIGURATION OF WELL WQSP-3	65
FIGURE 9	AS-BUILT CONFIGURATION OF WELL WQSP-4	66
FIGURE 10	AS-BUILT CONFIGURATION OF WELL WQSP-5	67
FIGURE 11	AS-BUILT CONFIGURATION OF WELL WQSP-6	68
FIGURE 12	AS-BUILT CONFIGURATION OF WELL WQSP-6a	69

Acronyms and Abbreviations

ASER	Annual Site Environmental Report
AR/VR	Approval/Variation Request
Bell Canyon	Bell Canyon Formation
bgs	below ground surface
Castile	Castile Formation
cm	centimeter(s)
Culebra	Culebra Member of the Rustler Formation
CofC	Chain of Custody
°C	degree(s) Celsius
%C	percent completeness
DI	deionized
DMP	Detection Monitoring Program
DOE	U.S. Department of Energy
DQO	data quality objectives
EM	Environmental Monitoring
EPA	U.S. Environmental Protection Agency
ES&H	Environment, Safety, and Health Department
FEIS	Final Environmental Impact Statement
ft	foot (feet)
ft^2	square foot (square feet)
g/cm^3	gram per cubic centimeter
GMP	Groundwater Monitoring Program
GWSP	Groundwater Surveillance Program
HWDU	hazardous waste disposal unit(s)
km	kilometer(s)
km^2	square kilometer(s)
$lb/in.^2$	pound(s) per square inch
LCS	laboratory control samples
LD	limit of detection
LWA	Land Withdrawal Act
m	meter(s)
M&DC	monitoring and data collection
m^2	square meter(s)
mg/L	milligram(s) per liter
mi	mile(s)
mi^2	square mile(s)
Mpa	megapascal(s)
mV	millivolt(s)
NIST	National Institute for Standards and Technology
NMAC	New Mexico Administrative Code
NMED	New Mexico Environment Department
PRS	Project Records Services

QA	Quality Assurance
QA/QC	quality assurance/quality control
QC	quality control
RCRA	Resource Conservation and Recovery Act
RFA	request for analysis
RIDS	Records Inventory and Disposition Schedule
RPD	relative percent difference
Rustler	Rustler Formation
%R	percent recovery
Salado	Salado Formation
SC	specific conductance
SOP	Standard Operating Procedure
STLB	sample tracking logbook
TDS	total dissolved solids
TOC	total organic carbon
TOX	total organic halogens
TRU	transuranic
TSDF	treatment, storage, and disposal facilities
TSS	total suspended solids
VOC	volatile organic compound
WID	Waste Isolation Division
WIPP	Waste Isolation Pilot Plant
WLMP	Water Level Monitoring Program
WQSP	Water Quality Sampling Program
µg/L	microgram(s) per liter
µm	micrometers

1.0 INTRODUCTION

This is the implementing document for the Waste Isolation Pilot Plant (WIPP) Groundwater Monitoring Program (GMP). The GMP ensures compliance with the Final WIPP Hazardous Waste Permit mandated by 20 NMAC 4 of the New Mexico Administrative Code incorporating applicable sections of 40 CFR 264 and 40 CFR 265. The GMP also ensures compliance with the WIPP Compliance Certification Application mandated by 40 CFR 191 and 40 CFR 194 of the Code of Federal Regulations. DOE orders 5400.1 and 5400.5, which were the driving documents for the previous groundwater surveillance program, now become secondary to the above mentioned regulatory drivers. The intent of the orders and subsequent documents required by these DOE orders continue to be implemented and carried out by the current GMP. A hierarchy of GMP governing documents are outlined in Figure 1.

The Waste Isolation Pilot Plant (WIPP) is a geologic repository for the disposal of transuranic (TRU) waste. The disposal horizon is located 2,150 feet (ft) (655 meters [m]) below the land surface in the bedded salt of the Salado Formation (hereinafter referred to as the Salado). At WIPP, water-bearing units occur both above and below the disposal horizon. Groundwater monitoring of the uppermost aquifer below the facility is not proposed at WIPP because that water-bearing unit (the Bell Canyon Formation) is not considered a credible pathway for a release from the repository. This is because the repository horizon and water-bearing sandstones of the Bell Canyon Formation are separated by over 2000 ft (610 m) of very low-permeability evaporite sediments. No natural credible pathway has been established for contaminant transport to aquifers below the repository horizon, as there is no hydrologic communication between the repository and underlying aquifers. The U.S. Environmental Protection Agency (EPA) concluded in 1990 that natural vertical communication does not exist based on their review of numerous studies (EPA, 1990). Furthermore, drilling boreholes for groundwater monitoring through the Salado and the Castile Formation (hereinafter referred to as the Castile) into the Bell Canyon aquifer would compromise the isolation properties of the repository medium.

Two types of waste are to be disposed of at the WIPP; TRU waste and TRU mixed waste. Disposal of TRU waste is subject to regulation under 40 CFR 191 and 40 CFR 194.

Disposal of TRU mixed waste in the WIPP facility is subject to regulation under Title 20 of the New Mexico Administrative Code, Chapter 4, Part 1, Subpart V (20 NMAC 4.1.500). As required by 20 NMAC 4.1.500 (incorporating 40 CFR § 264.601), the WIPP intends to demonstrate that the environmental performance standards for all regulatory requirements will be met.

Groundwater monitoring at WIPP in the past has focused on the Culebra member of the Rustler Formation (hereinafter referred to as the Culebra) because it represents the most significant hydrologic contaminant migration pathway to the accessible environment. The Culebra is the most significant water-bearing unit lying above the repository. Modeling of groundwater movement in the Culebra, based on the concept of a groundwater basin, is discussed in detail in Appendix D6, Section D6-2a(1), of the WIPP RCRA Part B Permit Application (DOE, 1997b). Groundwater modeling is also discussed in chapter six of the Compliance Certification Application (DOE, 1996b).

The WIPP site is located in Eddy County in southeastern New Mexico (Figure 2) within the Pecos Valley section of the southern Great Plains physiographic province (Powers et al., 1978). The site is 26 miles (mi) (42 kilometers [km]) east of Carlsbad, New Mexico in an area known as Los Medaños (the dunes). Los Medaños is a relatively flat, sparsely inhabited plateau with little water and limited land uses.

The WIPP site (Figure 2) consists of 16 sections of Federal land in Township 22 South, Range 31 East. The 16 sections of Federal land were withdrawn from the application of public land laws by the WIPP Land Withdrawal Act (LWA), Public Law 102-579. The WIPP LWA transferred the responsibility for the administration of the 16 sections from the Department of Interior, Bureau of Land Management, to the U.S. Department of Energy (DOE). This law specified that mining and drilling for purposes other than support of the WIPP project are prohibited within this 16 section area with the exception of Section 31. Oil and gas drilling activities are restricted in Section 31 from the surface down to 6,000 feet.

This monitoring plan addresses requirements for sample collection, groundwater surface elevation monitoring, groundwater flow direction, data management, and reporting of groundwater monitoring data. It also identifies analytical parameters selected to assess groundwater quality, and establishes personnel responsibilities for the WIPP groundwater detection monitoring program (DMP). Because quality assurance is an integral component of the groundwater sampling, analysis, and reporting process, quality assurance/quality control (QA/QC) elements and associated data acceptance criteria are included in this plan.

Instructions for performing field activities that will be conducted in conjunction with this sampling and analysis plan are provided in field operating procedures. Procedures are required for each aspect of the groundwater sampling process, including groundwater surface elevation measurement, groundwater flow direction, sampling equipment installation and operation, field water-quality measurements, and sample collection. These procedures prescribe proper field sampling techniques. Samples will be collected by trained personnel under the supervision and direction of qualified engineers, scientists, or other technical personnel.

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The New Mexico State Engineers Office has regulatory authority over the plugging and abandoning of groundwater production and monitoring wells in the state. The State of New Mexico has several groundwater basins, with each basin having it's own district office providing oversight of groundwater issues. The WIPP area is under the jurisdiction of the Roswell, New Mexico branch of the State Engineers Office. The Roswell office will be the regulatory body to approve the WIPP plans for well P&A.

A proposal may be made to P&A a DMW by submitting a permit modification request to the Secretary in compliance with 20 NMAC 4.1.900 (incorporating 40 CFR 270.42). The DMW must be plugged and abandoned in a manner which eliminates physical hazards, prevents groundwater contamination, conserves hydrostatic head, and prevents intermixing of subsurface water. A report will be submitted to the NMED which summarizes and certifies DMW plugging and abandoning methods within ninety (90) calendar days from the date a DMW is removed from the DMP.

6.0 MONITORING PROGRAM DESCRIPTION

The WIPP DMP has been designed to meet the groundwater monitoring requirements of 20 NMAC 4.1.500 (incorporating 40 CFR §§ 264.90 through 264.101) and the CCA. The following sections of the monitoring plan specify the components of the DMP.

6.1 Monitoring Frequency

The seven RCRA monitoring wells have been sampled on a semiannual basis since their installation in 1995 to establish background groundwater quality in accordance with 20 NMAC 4.1.500 (incorporating 40 CFR §§ 264.97 and 264.98). This has included at least two full rounds of 20 NMAC 4.1.500 (incorporating 40 CFR § 264) Appendix IX analysis for samples from each of the proposed RCRA detection monitoring wells. In addition, groundwater samples were collected from the DMP wells (from March 1997 until waste emplacement) at a frequency of four sample replicates collected semiannually from each well for the indicator parameters of pH, specific conductance (SC), total organic carbon (TOC), and total organic halogen (TOX) to further establish background groundwater quality until detection monitoring in accordance with 20 NMAC 4.1.500 (incorporating 40 CFR § 264.98) becomes applicable. A total of four rounds of Appendix IX analysis will be conducted for samples from each well for use in background groundwater quality determinations.

Detection monitoring will start with the emplacement of waste and continue through the post-closure phase as required by 20 NMAC 4.1.500 (incorporating 40 CFR § 264.90[c]). During detection monitoring, one sample and one sample duplicate will be collected semiannually from each well in the RCRA detection monitoring network. As shown in Table 2, the DMP will continue to collect groundwater quality samples for all seven wells on a semiannual basis during the life of the DMP. 20 NMAC 4.1.500 (incorporating 40 CFR §264.97[g][2]) provides that an alternate sampling frequency to that provided in 20 NMAC 4.1.500 (incorporating 40 CFR § 264.98) may be proposed. Given the nature and rate of groundwater flow in the area surrounding WIPP, collecting and analyzing one sample semiannually will be protective of human health and the environment because any hazardous constituent leaving the underground disposal facility will not have the potential to migrate beyond the groundwater monitoring network in a one-year time frame. Groundwater flow characteristics are presented in detail in Appendices D6 and E1 of the RCRA Part B Permit Application (DOE, 1997b) and appendix Hydro of the CCA (DOE, 1996b).

Groundwater surface elevations will be monitored in each of the seven DMP wells on a monthly basis. The groundwater surface elevation in each DMP well will also be measured prior to each sampling event. Groundwater surface elevation measurements in the other existing WQSP well sites will also be monitored on a monthly basis to supplement the area water-level database and to help define regional changes in groundwater flow directions and gradients. The characteristics of the RCRA DMP (frequency, location) will be evaluated if significant changes are observed in the groundwater flow direction or gradient. If any change occurs which could affect the ability of the DMP to fulfill the requirements of 20 NMAC 4.1.500 (incorporating 40 CFR § 264 Subpart F), the proper notifications and actions will be taken to comply with applicable permit requirements (Table 5).

6.2 Analytical Parameters

The analytes of interest measured to establish background groundwater quality prior to emplacement of waste include all indicator parameters and all other parameters listed in 20 NMAC 4.1.500 (incorporating 40 CFR § 264) Appendix IX. Field measurements of pH, SC, temperature, chloride, Eh, total iron, and alkalinity are also measured during background sampling.

The DMP will be initiated upon waste emplacement, at which time the semiannual samples will be analyzed for the parameters listed in Table 3. Parameters to be analyzed by the contract laboratory such as specific conductance, total dissolved solids, total suspended solids, density, pH, total organic carbon, and total organic halogens were included as indicator parameters because of their universal commonality to ground water. Parameters such as chloride, alkalinity, calcium, magnesium, and potassium were included as matrix-specific general indicator parameters. Calcium, magnesium, potassium, chloride, and iron may be deleted during detection monitoring, with prior approval of NMED. Organic and inorganic compounds on the right hand side of Table 3 were chosen because they will occur in the waste to be disposed at the WIPP facility. Additional parameters may be identified through the tentatively identified compound (TIC) process resulting from a library search performed by the contracted Laboratory. If compounds are identified, these will be added to the DMP list, unless omission of these compounds is justified, and this omission is approved by NMED.

6.3 Groundwater Surface Elevation Measurement, Sample Collection and Laboratory Analysis

Groundwater surface elevations will be measured in each well prior to groundwater sample collection. Ground water will be extracted using serial and final sampling methods. Serial samples will be collected until groundwater field indicator parameters stabilize, after which the final sample for complete analysis will be collected. Final samples will then be analyzed for the DMP analytical suite.

6.3.1 Groundwater Surface Elevation Monitoring Methodology

The WIPP Water Level Monitoring Program (WLMP) is a subprogram of the DMP. The quality assurance activities of the WLMP are in strict accordance with the WID Quality Assurance Program Description (QAPD), WP 13-1, and the quality assurance implementing procedures specific to groundwater surface elevation monitoring. Groundwater surface elevation monitoring is in progress now and will continue through the post-closure care period. This section of the plan addresses the activities of the WLMP during the preoperational and operational phases of WIPP.

Collection of groundwater surface elevation data is required by 20 NMAC 4.1.500 (incorporating 40 CFR § 264.97(f)) and 40 CFR 191 Performance Assessment. These data also provide:

- Data collection as required by the Environmental Monitoring Plan.
- A means to fulfill commitments made in the Final Environmental Impact Statement (FEIS).
- A means to comply with future groundwater inventory and monitoring regulations.
- Input for making land use decisions, (i.e., designing long-term active and passive institutional controls for the site).
- Assistance in understanding any changes to readings from the water-pressure transducers installed in each of the shafts to monitor water conditions behind the liners.
- An understanding of whether or not the horizontal and vertical gradients of flow are changing over time.

The objective of the WLMP is to extend the documented record of groundwater surface elevation fluctuations in the Culebra and Magenta members of the Rustler in the vicinity of the WIPP facility and to meet the requirements of 20 NMAC 4.1.500 (incorporating 40 CFR § 264.97(f)) and 40 CFR 191, Performance Assessment, and 40 CFR 194.42, Monitoring. Groundwater surface elevation data will be collected from each well of the RCRA DMP. Groundwater surface elevation data will also be collected from other Culebra wells, as well as monitoring wells completed in other water-bearing zones overlying and underlying the WIPP repository horizon when access to those zones is possible (Figure 5). This includes, but is not limited to, the Bell Canyon, the Forty-niner, the contact zone between the Rustler and Salado, and the Dewey Lake.

Groundwater surface elevation measurements will be taken monthly in at least one accessible completed interval at each available well pad. At well pads with two or more wells completed in the same interval, quarterly measurements will be taken in the redundant wells. Groundwater surface elevation measurements will be taken monthly at each of the seven DMP wells, as well as prior to each sampling event. If a cumulative groundwater surface elevation change of more than 2 feet is detected in any DMP well over the course of one year which is not attributable to site tests or natural stabilization of the site hydrologic system, notification will be made to NMED in writing and discuss the origin of the changes in the report specified in Permit Module V. Abnormal, unexplained changes in groundwater surface elevation may indicate changes in site recharge/discharge which could affect the assumptions regarding DMP well placement and constitute new information as specified in 20 NMAC 4.1.900 (incorporating
40 CFR § 70.41(a)(2)).

Groundwater surface elevation monitoring will continue through the post-closure care period. The frequency of monitoring may be temporarily increased to effectively document naturally occurring or artificial perturbations that may be imposed on the hydrologic systems at any point in time. This will be conducted in selected key wells by increasing the frequency of the manual groundwater surface elevation measurements or by monitoring water pressures with the aid of electronic pressure transducers and remote data-logging systems. Such additional data will be included in the reports specified in Section V.J.2 of the RCRA permit.

Interpretation of groundwater surface elevation measurements and corresponding fluctuations over time is complicated at WIPP by spatial variation in fluid density both vertically in well bores and areally from well to well. To monitor the hydraulic gradients of the hydrologic flow systems at WIPP accurately, actual groundwater surface elevation measurements will be monitored at the frequencies specified in Table 2, and the densities of the fluids in the well bores will be measured annually. When both of these parameters are known, equivalent freshwater heads can be calculated. The concept of freshwater head is discussed in Lusczynski (1961).

A discussion explaining the calculation of freshwater heads from mid-formation depth at WIPP can be found in Haug, et al (1987). Freshwater heads are useful in identifying hydraulic gradients in aquifers of variable density such as those existing at the WIPP site. Freshwater head at a given point is defined as the height of a column of freshwater that will balance the existing pressure at that point (Lusczynski, 1961).

Measured groundwater surface elevation data can be converted to equivalent freshwater head from knowledge of the density of the borehole fluid, using the following formula.

$$p = \rho g h$$

where

p = freshwater head (pressure)
ρ = average specific gravity of the borehole fluid (unitless)
g = freshwater density (mass/volume)
h = fluid column height above the datum (length)

If the freshwater density is assumed to be 1.000 gram per cubic centimeter (g/cm^3), then the equivalent freshwater head is equal to the fluid column height times the average borehole fluid density (expressed as specific gravity).

Groundwater surface elevation data will be used to determine the direction and rate of flow in the Culebra at least annually. The results of the determination of direction and flow rate will be presented annually in the Site Environmental Report.

6.3.2 Field Methods and Data Collection Requirements

To obtain an accurate groundwater surface elevation measurement, a calibrated water-level measuring device will be lowered into a test well and the depth to water recorded from a known reference point. When using an electrical conductance probe, the depth to water will be determined by reading the appropriate measurement markings on the embossed measuring tape when the alarm is activated at the surface. WIPP procedures specify the methods to be used in obtaining groundwater-level measurements.

6.3.3 Groundwater Surface Elevation Records and Document Control

All incoming data will be processed in a timely manner to assure data integrity. The data management process for groundwater surface elevation measurements will begin with completion of the field data sheets. Date, time, tape measurement, equipment identification number, calibration due date, initial of the field personnel, and equipment/comments will be recorded on the field data sheets. If, for some unexpected reason, a measurement is not possible (i.e., a test is under way that blocks entry to the well bore), then a notation as to why the measurement was not taken will be recorded in the comment column. Personnel will also use the comment column to report any security observations (i.e., well lock missing).

Data recorded on the field data sheets and submitted by field personnel will be subject to guidelines outlined in WIPP environmental procedures. These procedures specify the processes for administering and managing such data. The data will be entered onto a computerized work sheet. The work sheet will calculate groundwater surface elevation in both feet and meters relative to the top of the casing and also relative to mean sea level. The work sheet will also adjust groundwater surface elevations to equivalent freshwater heads.

A check print will be made of the work sheet printout. The check print will be used to verify that data taken in the field was properly reported on the database printout. A minimum of 10 percent of the spreadsheet calculations will be randomly verified on the check print to ensure that calculations are being performed correctly. If errors are found, the work sheet will be corrected. The data contained on the computerized work sheet will be translated into a database file. A printout will be made of the database file. The data each month will then be compiled into report format and transmitted to the appropriate agencies as requested by the CAO. Groundwater surface elevation data and equivalent freshwater heads for all Culebra wells will be transmitted to NMED one month after data are collected.

A computerized database file will be maintained for all groundwater surface elevation data. Monthly and quarterly data will be appended into a yearly file. Upon verification that the yearly database is free of errors, it will be appended into the project database file. A printed copy of the current project database (through December of the preceding year) will be kept in the Environment, Safety and Health Department (ES&H) EM fire-resistant storage area (Operating Record).

6.4 Groundwater Sampling

6.4.1 Groundwater Pumping and Sampling Systems

The water-bearing units at WIPP are highly variable in their ability to yield water to monitoring wells. The Culebra, the most transmissive hydrologic unit in the WIPP area, exhibits transmissivities that range many orders of magnitude across the site area and is the primary focus of the DMP.

The groundwater pumping and sampling systems used to collect a groundwater sample from the seven DMP wells will provide continuous and adequate production of water so that a representative groundwater sample can be obtained. The wells used for groundwater quality sampling vary in yield, depth, and pumping lift. These factors affect the duration of pumping as well as the equipment required at each well.

The type of pumping and sampling system to be used in a well depends primarily on the aquifer characteristics of the Culebra and well construction. The DMP wells will be individually equipped with dedicated submersible pumping assemblies. Each well has a specific type of submersible pump, matched to the ability of the well to yield water during pumping. The down hole submersible pumps will be controlled by a variable electronic flow controller to match the production capacity of the formation at each well. The electronic flow controller allows personnel collecting samples to control the rate of discharge during well purging to minimize the potential for loss of volatiles from the sample. As recommended in the "RCRA Groundwater Monitoring Technical Enforcement Guidance Document" (EPA, 1986) the wells will be purged a minimum of three well bore volumes at a rate that will minimize the agitation of recharge water. This will be accomplished by monitoring formation pressure and matching the rate of discharge from the well as nearly as possible to the rate of recharge to the well. WIPP procedures specify the methods used for controlling flow rates and monitoring formation pressure. Well purging requirements will be used in conjunction with serial sampling to determine when the groundwater chemistry stabilizes and is therefore representative of undisturbed ground water.

The DMP wells will be cased and screened through the production interval with materials that do not yield contamination to the aquifer or allow the production interval to collapse under stress (high epoxy fiberglass). An electric, submersible pump installation without the use of a packer will be used in this instance. The largest amount of discharge from the submersible pump will take place from a discharge pipe. In addition to this main discharge pipe a dedicated sample line, running parallel to the discharge pipe, will also be used. Flow through the pipe will be regulated on the surface by a flow control valve and/or variable speed drive controller. Cumulative flow will be measured using a totalizing flow meter. Flow from the discharge pipe will be routed to a discharge tank for disposal.

The dedicated sampling line will be used to collect the water sample that will undergo analysis. By using a dedicated sample line, the water will not be contaminated by the metal discharge pipe. The sample line will branch from the main discharge pipe a few inches above the pump. Flow from the sample line will be routed into the sample collection area. Flow through the sample collection line will be regulated by a flow-control valve. The sample line will be insulated at the surface to minimize temperature fluctuations.

6.4.2 Pressure Monitoring Systems

The DMP wells do not require the installation of a packer because sample biases due to well construction deficiencies are not present. However, pressures will be monitored using down hole automatic air line bubblers in the formation to maintain the water level above the pump intake. Pressure transducers may be used in line with bubblers to provide continual electronic monitoring through data acquisition systems. WIPP procedures provide instructions for monitoring formation pressure using automatic airline bubblers in conjunction with pressure transducers and data acquisition systems. The mobile field laboratory provides a work place for conducting field sampling and analyses. The laboratory will be positioned near the wellhead, will be climate controlled, and will contain the necessary equipment, reagents, glassware, and deionized water for conducting the various field analyses.

6.4.3 Sampling Overview

Two types of water samples will be collected: serial samples and final samples. Serial samples will be taken at regular intervals and analyzed in the mobile field laboratory for various physical and chemical parameters (called field indicator parameters). The serial sample data will be used to determine whether the sample is representative of undisturbed ground water as a direct function of the stabilization of field indicator parameters and the volume of the water being pumped from the well. Interpretation of the serial sampling data will enable the Team Leader to determine when conditions representative of undisturbed ground water are attained in the pumped ground water.

Final samples will be collected when the serially sampled field indicator parameters have stabilized and are therefore representative of undisturbed ground water.

a. Serial Samples

Serial sampling is the collection of sequential samples for the purpose of determining when the groundwater chemistry stabilizes and is therefore representative of undisturbed ground water. A serial sample is considered representative of undisturbed ground water when the majority of field indicator parameter measurements have stabilized within ±5 percent of the average of analytical results for the field indicator parameter from the background groundwater quality for each DMP well. Nonstabilization of one or two field indicator parameters attributable to matrix interferences, instrument drift, or other unforeseen reasons will not preclude the collection of final samples, provided the volume of purged water exceeds three well bore volumes. Final samples collected, when field indicator parameters were not stabilized, will be reported in the operating record, and an explanation of why the sample was collected when field indicator parameters were not stabilized will be provided.

Serial samples will be collected and analyzed to detect and monitor the chemical variation of the ground water as a function of the volume of water pumped. Once serial sampling begins, the frequency at which serial samples are collected and analyzed will be left to the discretion of the Team Leader, but will be performed a minimum of three times during a sampling round.

The appropriate field methods to identify stabilization of the following field indicator parameters: chloride, divalent cations (hardness), alkalinity, total iron, pH, Eh, temperature, specific conductance, and specific gravity will be used. Protocols for collection of serial samples are specified in WIPP procedures.

The three field indicator parameters of temperature, Eh, and pH will be determined by either an "in-line" technique, using a self-contained flow cell, or an "off-line" technique, in which the samples will be collected from a sample line at atmospheric pressure. The iron, divalent cation, chloride, alkalinity, specific conductance, and specific gravity samples will be collected from the nylon sample line at atmospheric pressure. Because of the lack of sophisticated weights and measures equipment available for field density assessments, field density evaluations will be expressed in terms of specific gravity, which is a unitless measure. Density is expressed as unit weight per unit volume.

New polyethylene containers will be used to collect the serial samples from the sample line. Serial sampling water collected for solute and specific conductance determinations will be filtered through a 0.45 micrometers (µm) membrane filter using a stainless-steel, in-line filter holder. Filtered water will be used to rinse the sample bottle prior to serial sample collection. Unfiltered ground water will be used when determining temperature, pH, Eh, and specific gravity. Sample bottles will be properly identified and labeled.

The filtered sample collected for solute analyses will be immediately analyzed for iron and alkalinity because these two solution parameters are extremely sensitive to changes in the ambient water-sample pressure and temperature. A sample and duplicate of filtered water will be collected and analyzed for solute parameters (alkalinity, chloride, divalent cations, and iron). Temperature, pH, and Eh, when not measured in a flow cell, will be measured at the approximate time of serial sample collection. These samples will be collected from the unfiltered sample line.

Samples to be analyzed for chloride and divalent cations (after preservation with nitric acid and stored at 4°C) may be stored for one week prior to analysis with confidence that the analytical results will not be altered.

Upon completion of the collection of the last serial sample suite, the serial sample bottles accrued throughout the duration of the pumping of the well will be discarded. No serial sample bottles will be reused for sampling purposes of any sort. However, serial samples may be stored for a period of time depending upon the need.

During the first two years of DMP well serial sampling, the first sample will be analyzed as soon as possible after the pump is turned on and daily thereafter for a period of four days or until the field indicator parameters (chloride, divalent cations, alkalinity, and iron) stabilize. Eh, pH, and SC will be continually monitored by using a flow cell with ion-specific electrodes and a real-time readout. When detection monitoring begins, the serial sampling process may be modified and the decision to collect final samples would then be based on the number of well bore volumes purged and results of the analysis of chloride, temperature, specific gravity, pH, Eh, and SC. Removal of serial sampling from the DMP will be accomplished through a permit modification and a modification to this plan.

b. Final Samples

The final sample will be collected once the measured field indicator parameters have stabilized. A serial sample will also be collected and analyzed for each day of final sampling to ensure that samples collected for laboratory analysis are still representative of stable conditions. Sample preservation, handling, and transportation methods will maintain the integrity and representativeness of the final samples.

Prior to collecting the final samples, the collection team shall consider the analyses to be performed so that proper shipping or storage containers can be assembled. Table 4 presents the sample containers, volumes, and holding times for laboratory samples collected as part of the DMP.

The monitoring system will use dedicated pumping systems and sample collection lines from the sampled formation to the well head. Non-dedicated sample collection lines from the well head to the sample collection area will be discarded after each use.

Sample integrity will be ensured through appropriate decontamination procedures. Laboratory glassware will be washed after each use with a solution of nonphosphorus detergent and deionized (DI) water and rinsed in DI water. Sample containers will be new, certified clean containers that will be discarded after one use. Groundwater surface elevation measurement devices will be rinsed with fresh water after each use. Non-dedicated sample collection manifold assemblies will be rinsed with two gallons of fresh water, then rinsed with five gallons of 5 percent nitric acid solution and rinsed with five gallons of DI water after each use. The exposed ends will be capped off during storage. Prior to the next use of the sampling manifold, it will be rinsed a second time with DI water and a blank rinsate sample will be collected to verify decontamination.

Water samples will be collected at atmospheric pressure using either the filtered or unfiltered sampling lines branching from the main sample line. Detailed protocols, in the form of procedures, assure that final samples will be collected in a consistent and repeatable fashion.

Final samples will be collected in the appropriate type of container for the specific analysis to be performed. The samples will be collected in new and unused glass and plastic containers (refer to Table 4). For each parameter analyzed, a sufficient volume of sample will be collected to satisfy the volume requirements of the analytical laboratory (as specified by laboratory Standard Operating Procedures [SOPs]). This includes an additional volume of sample water necessary for maintaining quality control standards. All final samples will be treated, handled, and preserved as required for the specific type of analysis to be performed. Details about sample containers, preservation, and volumes required for individual types of analyses are found in the applicable procedures generated, approved, and maintained by the contract analytical laboratory.

Before the final sample is taken, all plastic and glass containers will be rinsed with the pumped ground water, either filtered or unfiltered, dependent upon analysis protocol. When the rinsing procedure is completed the final sample will be collected.

Final samples will be sent to contract laboratories and analyzed for general chemistry, radionuclides, metals, and selected VOCs that are specific to the waste anticipated to arrive at WIPP. Table 3 presents the specific analytes for the DMP.

WIPP has not accepted TRU mixed waste for disposal prior to issuance of a hazardous waste disposal permit, and previous WQSP sample analyses have shown that requested hazardous constituents have not been introduced to the ground water in the vicinity of WIPP by other activities. Appendix D18, Attachment A, of the RCRA Part B Permit Application (DOE, 1997b) presented analytical data obtained from WQSP wells 1-6 which indicated that, for the Appendix IX parameters analyzed for, none of the anticipated waste constituents presented on Table 3 were present in sampled ground water at WIPP.

Duplicates of the final sample will be provided to WIPP oversight agencies as requested by the CAO or NMED.

Resulting wastes are disposed of in accordance with the WID "Site Generated, Non-Radioactive Hazardous Waste Management Plan," WP 02 -RC.01.

6.4.4 Sample Preservation, Tracking, Packaging, and Transportation

Many of the chemical constituents measured by the DMP are not chemically stable and require preservation and special handling techniques. Samples requiring acidification will be treated with either high purity hydrochloric acid, nitric acid, or sulfuric acid (ULTREX or equivalent), depending upon the standard method of treatment required for the particular parameter suite or as requested by contract laboratory SOPs (see Table 4).

The contract laboratory receiving the samples will use procedures that prescribe the type and amount of preservative, the container material type, and the required sample volumes that shall be collected. This information will be recorded on the Final Sample Checklist for use by field personnel when final samples are being collected. EPA "RCRA Groundwater Monitoring Technical Enforcement Guidance Document," Table 4-1 (EPA, 1986), will be followed if laboratory SOPs do not specify sample container, volume, or preservation requirements.

The sample tracking system at WIPP will use uniquely numbered chain of custody (CofC) Forms and request for analysis (RFA) Forms. The primary consideration for storage or transportation is that samples shall be analyzed within the prescribed holding times for the parameters of interest. WIPP procedures provide instructions to ensure proper sample tracking protocol.

Insulated shipping containers packaged with crushed ice or reusable ice packs will be used to keep the samples cool during transport to the contract laboratory. Holding times for specific analytical parameters require samples to be shipped by express air freight. The coolers will be packaged to meet Department of Transportation and International Air Transportation Association commercial carrier regulations.

6.4.5 Sample Documentation and Custody

To ensure the integrity of samples from the time of collection through reporting date, sample collection, handling, and custody shall be documented. Sample custody and documentation for EM sampling and analysis activities are detailed in WIPP procedures. These procedures will be strictly followed throughout the course of each sample collection and analysis event.

Standardized forms used to document samples will include sample identification numbers, sample labels, custody tape, the sample tracking log books, and the request for analysis/chain of custody (RFA and CofC) form. The forms are briefly defined in the following subsections.

All sample documentation will be completed for each sample and reviewed by the Team Leader or his/her designee for completeness and accuracy.

a. Sample Numbers and Labels

A unique sample identification number will be assigned to each sample sent to the laboratory for analysis. The Team Leader will assign the numbers prior to sample collection. The sample identification numbers will be used to track the sample from the time of collection through data reporting. Every sample container sent to the laboratory for analysis will be identified with a label affixed to it. Sample label information will be completed in permanent, indelible ink and will contain the following information: sample identification number with sample matrix type; sample location; analysis requested; time and date of collection; preservative(s), if any; and the sampler's name or initials.

b. Custody Seals

Custody seals will be used to detect unauthorized sample tampering from collection through analysis. The custody seals will be adhesive-backed strips that are destroyed when removed or when the container is opened. The seal will be dated, initialed, and affixed to the sample container in such a manner that it is necessary to break the seal to open the container. Seals will be affixed to sample containers in the field immediately after collection. Upon receipt at the laboratory, the laboratory custodian will inspect the seal for integrity; a broken seal will invalidate the sample.

c. Sample Tracking Logbook

A sample tracking logbook (STLB) form will be completed for each sample collected. The STLB will include the following information: C of C number; RFA No.; date sample(s) were sent to the lab; laboratory name; acknowledgment of receipt or comments; well name and round number. Sample codes will indicate the well location; the geologic formation where the water was collected from, the sampling round number; and the sample number. The code is broken down as follows:

WQ6[1]C[2]R2[3]N1[4]

[1] Well identification (e.g., WQSP-6 in this case)
[2] Geologic formation (e.g., the Culebra in this case)
[3] Sample round no. (Round 2)
[4] Sample no. (N1)

To distinguish duplicate samples from other samples, a "D" is added as the last digit to signify a duplicate. STLB information will be completed in the field by the sampling team and checked by the Team Leader. When samples are shipped, the STLB will remain in the custody of the EM Section for sample tracking purposes.

d. Request for Analysis and Chain of Custody

An RFA and CofC form will be completed during or immediately following sample collection and will accompany the sample through analysis and disposal. The RFA and CofC form will be signed and dated each time the sample custody is transferred.
A sample will be considered to be in a person's custody if: the sample is in his/her physical possession; the sample is in his/her unobstructed view; and/or the sample is placed, by the last person in possession of it, in a secured area with restricted access. During shipment, the carrier's air bill number serves as custody verification. Upon receipt of the samples at the laboratory, the laboratory sample custodian acknowledges possession of the samples by signing and dating the RFA and CofC. The completed

original (top page) of the RFA and CofC will be returned to the Team Leader with the laboratory analytical report and becomes part of the permanent record of the sampling event. The RFA and CofC form also contains specific instructions to the laboratory for sample analysis, potential hazards, and disposal instructions.

6.5 Laboratory Analysis

Analysis of samples will be performed by a commercial laboratory. Methods will be specified in procurement documents and will be selected to be consistent with EPA recommended procedures in SW 846 (EPA, 1996). Additional detail on analytical techniques and methods will be given in laboratory SOPs. Table 3 presents the analytical parameters for the WIPP DMP.

The WID has established criteria for laboratory selection, including the stipulation that the laboratory follow the procedures specified in SW 846 and that the laboratory follow EPA protocols. The selected laboratory shall demonstrate, through laboratory SOPs, that it will follow appropriate EPA SW 846 requirements and the requirements specified by the EPA protocols. The laboratory shall also provide documentation to the WIPP describing the sensitivity of laboratory instrumentation. This documentation will be retained in the facility operating record and will be available for review upon request by an authorized agency. Instrumentation sensitivity needs to be considered because of regulatory requirements governing constituent concentrations in ground water and the complexity of brines associated with the WIPP repository.

Once the initial qualification criteria, as specified above, have been met, a laboratory will be selected based upon competitive bid. The selected laboratory will perform analytical work for the DMP for a predetermined period of time, as specified in the contract between the WID and the selected laboratory. As this period of performance comes to an end, a new laboratory selection/competitive bid process will be initiated by the DMP. The same or a different laboratory may be selected for the new contract period. The SOPs for the laboratory currently under contract will be maintained in a file in the operating record. An initial set of SOPs will be provided to the NMED for information purposes along with any SOP updates on an annual basis.

Data validation will be performed by WID Environmental Monitoring. Data validation results are documented on an Approval/Variation Request (AR/VR) form. If no discrepancies are found in the data, the AR/VR form will be signed and the approved box will be checked. If however, discrepancies are found, the AR/VR form will be signed and the disapproved or approved-on-condition box will be checked and the form will be returned to the team leader accompanied by an attached report discussing the data validation results, any anomalies, and resolutions. Copies of the data validation report will be distributed to the EM Manager, QA Manager, the Team Leader, and the Contract Administrator. Copies of the data validation report will be kept on file in the EM records section for review upon request by NMED.

7.0 CALIBRATION

7.1 Sampling Equipment Calibration Requirements

The equipment used to collect data for the WQSP and this DMP will be calibrated in accordance with maintenance administrative procedures. The EM Section will be responsible for calibrating needed equipment on schedule, in accordance with written procedures. The EM Section will also be responsible for maintaining current calibration records for each piece of equipment.

7.2 Groundwater Surface Elevation Monitoring Equipment Calibration Requirements

The equipment used in taking groundwater surface elevation measurements will be maintained in accordance with WIPP procedures. The EM Section will be responsible for calibrating the needed equipment on schedule in accordance with written procedures. The EM Section will also be responsible for maintaining current calibration records for each piece of equipment.

8.0 STATISTICAL ANALYSIS OF LABORATORY DATA

As required by 20 NMAC 4.1.500 (incorporating 40 CFR §§ 264.97 and 264.98), data collected to establish background groundwater quality and as part of the DMP will be evaluated using appropriate statistical techniques. The following specifies the statistical analysis to be performed by the DMP. Statistical analysis of DMP data will conform to EPA guidance "Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities (EPA, 1989), "Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities, Addendum to Interim Final Guidance" (EPA, 1992), and DOE/EH-0173T, "Environmental Regulatory Guide for Radiological Effluent Monitoring and Environmental Surveillance".

8.1 Temporal and Spatial Analysis

Environmental parameters vary with space and time. The effect of one or both of these two factors on the expected value of a point measurement will be statistically evaluated through spatial analysis and time series analysis. These methods often require extensive sampling efforts that may exceed the practical limits of the DMP sampling procedures.

Spatial analysis may have limited use during the operational period, although the effect of spatial auto-correlation on the interpretation of the data will be considered for each parameter. Spatial variability will be accounted for by the use of predetermined key sampling locations. Data analysis will be performed on a location-specific basis, or data from different locations will be combined only when the data are statistically homogeneous. Statistical homogeneity will be determined by evaluating mean values and variances from the residuals from the individual well data.

Time series analysis plays a more important role in data analysis for the DMP. Parameters will be reported as time series, either in tabular form or as time plots. For key time series parameters, these plots will be in the form of control charts on which control levels will be identified based on preoperational database, fixed standards, control location databases, or other standards for comparison. Where significant seasonal changes in the expected value of the parameter are identified in the preoperational database or in the control locations, corrections in the control levels which reflect the seasonal change will be made and documented.

8.2 Distributions and Descriptive Statistics

For data sets which include more than ten data points that are homogeneous in space and time (including seasonal homogeneity) and have less than ten percent missing data, a test for conformance to the normal distribution will be performed. The test for normality of the data will be performed in accordance with the methodologies presented in "Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities, Addendum to Interim Final Guidance" (EPA, 1992). Examples of test performed on the data are Shapiro-Wilk Test or Olmogorov-Smirnov Test at the 95% confidence level, there is only a one-in-twenty chance of falsely identifying the distribution as normal when it really is not.

If normality is not met, the data will be log-transformed (or transformed using a suitable mathematical transformation, e.g., square root) and retested for normality. If the transformed data fit a normal distribution, the original data will be accepted as having lognormal or an otherwise mathematically-transformed normal distribution. If normality is still not found, two courses may be taken. One will be to continue to test the fit to standard families of distributions, such as the gamma, beta, and Weibull, with proper modifications to subsequent analyses based on these results. The other course will be to use nonparametric methods of data analysis. Non-radiological data sets with greater than 15 percent nondetect are automatically treated as nonparameteric distributions.

For data sets smaller than ten, but homogeneous and complete, the lognormal distribution will be assumed. Data sets with more than ten percent missing data will be analyzed using nonparametric methods. Nonhomogeneous data sets will be subdivided into homogeneous sets and each of these analyzed individually.

Descriptive statistics will be calculated for each homogeneous data set. At a minimum, these include a central value and a range of variation. The central value is the arithmetic mean of the untransformed data if the data are not censored at either end. If the data are censored, either a trimmed mean or the median will be used as the central value (which may be within the censored range). If the data set is greater than ten and is uncensored, the standard deviation will be calculated and used as a basis for the reported range in variation. If these criteria are not met, the range between the 0.25 and 0.75 cartelist will be used. Radiological normally distributed data with a small number of extreme or less than detectable values, the arithmetic mean is the estimator of central tendency. When data set contains large extreme values, the median, which is less sensitive to extreme values than the mean, will be used to summarize the data. All of the actual values, including those that are negative will be included in the statistical analysis for radiological data. Radiological data will also be transformed to approximate a normal distribution before the central values are calculated. Most often a log transformation will normalize environmental data.

8.3 Data Anomalies

Data anomalies include data points reported as being below the limit of detection (LD) or otherwise censored over a specific range of values, missing data points occurring randomly in the data set, and outliers that cannot be ascribed to a known source of variation.

Whenever possible, sample values which are reported below detection limits will be incorporated into the database as sample values measured at one-half the detection limit for statistical analysis. When values are not available, alternative methods of analysis, as specified in previous sections, will be used. In particular, the use of nonparametric statistics will be required.

Missing data points comprising less than 10 percent of the data set do not significantly affect data analyses. Results based on data in which more than 10 percent is missing will be identified as such at the time of reporting. Consideration of the potential effect of missing data shall be made when the majority of the data are missing from a discrete time span.

Formal testing for outliers will only be done in accordance with EPA guidance.
The methodologies specified in Section 8.2 of the "Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities" (EPA, 1989) will be used to check for outliers.

If an outside source of variation is not identified to account for outliers in a data set, it will be included in the data set and all subsequent analyses. If the inclusion of such outliers is found to affect the final results of the analyses significantly, both results (with and without outliers) will be reported. Radiological outliers will be tested with respect to the mean or median of the entire data set for outliers. Trend analyses on radiochemical data will be performed by comparing the results for the current year with the results of last several years to identify changes or inconsistencies in the results. Radiological data will also be plotted in time series for historical comparison. Data points falling outside ± 3 standard deviations could be considered outliers. Time plot and other yearly or seasonal trends in the data should be considered to reject/accept outliers.

9.0 COMPARISONS AND REPORTING

Prior to waste receipt, measurements will have been made of each background groundwater quality parameter and constituent specified in Table 3 at every DMP groundwater monitoring well during each of the four background sampling events. If any background groundwater quality parameter or constituent has not been measured prior to waste receipt, measurements will be made for those parameters or constituents in hydraulically upgradient DMP groundwater monitoring wells for a sequence of four sampling events. Following completion of the four sampling events, the arithmetic mean and variance shall then be calculated by the field supervisor or designee for each well. These measurements will then serve as a background value against which statistical values for subsequent sampling events during detection monitoring will be compared. Statistical analysis and comparison will be accomplished within sixty (60) days after the final sample is taken, using one of the five statistical tests specified in 20 NMAC 4.1.500 (incorporating 40 CFR § 264.98(h)), which may include Cochran's Approximation to the Behrens-Fisher students' t-test at the 0.01 level of significance (described in Appendix IV to 20 NMAC 4.1.500 (incorporating 40 CFR §264). If the comparisons show a significant increase at any monitoring site (as defined in 20 NMAC 4.1.500 (incorporating 40 CFR § 264.98(f)), the well shall be resampled and an analysis performed as soon as possible, in accordance with 20 NMAC 4.1.500 (incorporating 40 CFR § 264.98(g)(2))(Final WIPP Hazardous Waste Permit Requirement V.J.3.b). The results of the statistical comparison will be reported annually in the Annual Site Environmental Report (ASER), and will be reported to NMED as stated in module V, section V.J.3 of the Final WIPP Hazardous Waste Permit and as required under 20 NMAC 4.1.500 (incorporating 40 CFR § 264.98(g)).

9.1 <u>Reporting</u>

9.1.1 Laboratory Data Reports

Laboratory data will be provided in electronic and hard copy reports. Laboratory data reports will be forwarded to the Team Leader and NMED and will contain the following information for each analytical report:

- A brief narrative summarizing laboratory analyses performed, date of issue, deviations from the analytical method, technical problems affecting data quality, laboratory quality checks, corrective actions (if any), and the project manager's signature approving issuance of the data report.

- Header information for each analytical data summary sheet including: sample number and corresponding laboratory identification number; sample matrix; date of collection, receipt, preparation and analysis; and analyst's name.

- Analytical parameter, analytical result, reporting units, reporting limit, analytical method used.

- Results of QC sample analyses for all concurrently analyzed QC samples.

9.1.2 Statistical Analysis and Reporting of Results

Analytical results from semi-annual groundwater sampling activities will be compared and interpreted by the Team Leader through generation of statistical analyses as specified in Section L-4e of the Final WIPP Hazardous Waste Permit. The Team Leader will perform statistical analyses; the results will be included in the ASER in summary form, and will also be provided to NMED as specified in Permit Module V (Final WIPP Hazardous Waste Permit section V.J.2).

9.1.3 Annual Site Environmental Report

Data collected from this DMP will be reported to NMED as specified in Permit Module V, and to the EM Manager and NMED in the ASER. The ASER will include all applicable information that may affect the comparison of background groundwater quality and groundwater surface elevation data through time. This information will include but is not limited to:

- Well configuration changes that may have occurred from the time of the last measurement (i.e., plug installation and removal, packer removal and reinstallation, or both; and the type and quantity of fluids that may have been introduced into the test wells).

- Any pumping activities that may have taken place since publication of the last annual report (i.e., groundwater quality sampling, hydraulic testing, and shaft installation or grouting activities).

The DMP data used in generating the ASER will be maintained as part of the WIPP operating record and will be provided to NMED for review as specified in the permit.

10.0 RECORDS MANAGEMENT

Records generated during groundwater sampling and groundwater surface elevation monitoring events will be maintained in the form project files (operating record) in the EM section. Project records will include, but are not limited to:

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Waste Isolation Pilot Plant 1999 Site Environmental Report

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Table of Contents

Acknowledgments iii

Executive Summary v

List of Tables xxv

List of Figures xxxi

Chapter 1 Introduction 1
- 1.1 WIPP History 1
- 1.2 WIPP's Mission 3
- 1.3 WIPP Location 3
  - 1.3.1 WIPP Property Areas 5
  - 1.3.2 Population 5
- 1.4 Environmental Performance 6

Chapter 2 Environmental Program Information 8
- 2.1 Environmental Monitoring Plan 8
- 2.2 WIPP Environmental Monitoring Program 8
- 2.3 Land Management Programs 10
  - 2.3.1 Land Use Requests 11
  - 2.3.2 Wildlife Population Monitoring 11
  - 2.3.3 Reclamation of Disturbed Lands 13
  - 2.3.4 Oil and Gas Surveillance 14
  - 2.3.5 Aerial Photography 15

Chapter 3 Compliance Summary 16
- 3.1 Compliance Overview 16
- 3.2 Compliance Status 16
  - 3.2.1 Comprehensive Environmental Response, Compensation, and Liability Act 16
  - 3.2.2 Federal Acquisition, Recycling, and Pollution Prevention 17
  - 3.2.3 Resource Conservation and Recovery Act 18
  - 3.2.4 National Environmental Policy Act 20
  - 3.2.5 Clean Air Act 21

3.2.6 Clean Water Act ... 22
3.2.7 Safe Drinking Water Act ... 23
3.2.8 National Historic Preservation Act ... 24
3.2.9 Hazardous Materials Transportation Act ... 24
3.2.10 Packaging and Transporting Radioactive Materials ... 24

3.3 Other Significant Accomplishments and Ongoing Compliance Activities ... 25
3.3.1 Environmental Compliance Assessment Program ... 25
3.3.2 ISO 14000 – Standards for Environmental Management ... 25
3.3.3 Pollution Prevention Committee ... 26
3.3.4 Environmental Training ... 26

Chapter 4 Environmental Radiological Program Information ... 34
4.1. Effluent Monitoring ... 34
4.2 Airborne Gross Alpha/Beta ... 36
4.3 Airborne Particulate ... 40
4.3.1 Sample Preparation ... 41
4.3.2 Determination of Individual Radionuclides ... 41
4.3.3 Results and Discussions ... 41
4.4 Ground Water ... 46
4.4.1 Sample Collection ... 46
4.4.2 Determination of Individual Radionuclides ... 46
4.4.3 Results and Discussions ... 46
4.5 Surface Water ... 50
4.5.1 Sample Collection ... 50
4.5.2 Determination of Individual Radionuclides ... 50
4.5.3 Results and Discussions ... 51
4.6 Soil Samples ... 56
4.6.1 Sampling ... 56
4.6.2 Sample Preparation ... 56
4.6.3 Determination of Individual Radionuclides ... 56
4.6.4 Results and Discussions ... 57
4.7 Sediments ... 63
4.7.1 Sample Collection ... 63
4.7.2 Sample Preparation ... 63
4.7.3 Determination of Individual Radionuclides ... 63
4.7.4 Results and Discussions ... 63
4.8 Biota ... 69
4.8.1 Sample Collection ... 69
4.8.2 Sample Preparation ... 69
4.8.3 Results and Discussions ... 69
4.9 Summary and Conclusion ... 70

Chapter 5 Environmental Nonradiological Program Information 76
5.1 Principal Functions of Nonradiological Sampling 76
5.2 WIPP Raptor Program 76
5.3 Meteorology 78
5.3.1 Climatic Data 78
5.3.2 Wind Direction and Wind Speed 78
5.4 Volatile Organic Compound Monitoring 78
5.5 Seismic Activity 87
5.6 Liquid Effluent Monitoring 90

Chapter 6 Ground-water Monitoring 91
6.1 Ground-water Quality Sampling 91
6.2 Ground-water Level Surveillance 96

Chapter 7 Radiological Dose Assessment 203
7.1 Introduction and Dose Limits 203
7.2 Background Radiation 204
7.3 Dose from Air Emissions 205
7.3.1 Maximally Exposed Individual from Air Emission Pathway 205
7.4 Total Potential Dose from WIPP Operations 206
7.4.1 Potential Dose from Water Ingestion Pathway 206
7.4.2 Potential Dose from Wild Game Ingestion 206
7.4.3 Total Potential Dose from All Pathways 206
7.5 Dose to non-human Biota 206

Chapter 8 Quality Assurance 209
8.1 Completeness 209
8.2 Reproducibility 210
8.3 Accuracy and Comparability 210
8.4 Representativeness 217

References 221

Appendix A Acronyms, Abbreviations, and Symbols 227

Appendix B Location Codes 232

Appendix C Concentrations of Alpha and Beta Activities in Air Particulate 233

Appendix D Equations 246

Appendix E Air Sampling Data: Mass of Particulates and Volumes of Air Samples 248

Appendix F Authors and Contributors 252

Executive Summary

The U.S. Department of Energy's (DOE) Carlsbad Area Office and the Westinghouse Waste Isolation Division (WID) are dedicated to maintaining high quality management of Waste Isolation Pilot Plant (WIPP) environmental resources. DOE Order 5400.1, *General Environmental Protection Program*, and DOE Order 231.1, *Environmental, Safety, and Health Reporting*, require that the environment at and near DOE facilities be monitored to ensure the safety and health of the public and the environment. This *Waste Isolation Pilot Plant 1999 Site Environmental Report* summarizes environmental data from calendar year 1999 that characterize environmental management performance and demonstrate compliance with federal and state regulations.

This report was prepared in accordance with DOE Order 5400.1, DOE Order 231.1, the *Environmental Regulatory Guide for Radiological Effluent Monitoring and Environmental Surveillance* (DOE/EH- 0173T), and the *Waste Isolation Pilot Plant Environmental Protection Implementation Plan* (DOE/WIPP 96-2199). The above orders and guidance documents require that DOE facilities submit an Annual Site Environmental Report to DOE Headquarters, Office of the Assistant Secretary for Environment, Safety, and Health. The purpose of this report is to provide a comprehensive description of operational environmental monitoring activities, to provide an abstract of environmental activities conducted to characterize site environmental management performance to confirm compliance with environmental standards and requirements, and to highlight significant programs and efforts of environmental merit at WIPP during calendar year 1999.

WIPP received its first shipment of waste on March 26, 1999. In 1999, no evidence was found of any adverse effects from WIPP on the surrounding environment. Radionuclide concentrations in the environment surrounding WIPP were not statistically higher in 1999 than in 1998.

Introduction

Located in southeastern New Mexico, WIPP is the world's first underground repository permitted to safely and permanently dispose of transuranic (TRU) radioactive and mixed waste generated through the research and production of nuclear weapons and other activities related to the national defense of the United States. TRU mixed waste is TRU waste mixed with hazardous waste regulated under the Resource Conservation and Recovery Act (RCRA). Transuranic waste consists of material contaminated with elements with atomic numbers greater than uranium, the heaviest natural element. Most TRU waste is contaminated industrial trash, such as rags, old tools, and rubbish from dismantled buildings.

WIPP's legislative mandatc is to demonstrate the safe disposal of TRU wastes from national defense activities and programs. To fulfill this mandate, WIPP has been designed to safely handle, store, and dispose of TRU waste in a fully-operational disposal facility. When waste arrives at WIPP, it is placed in excavated storage rooms, carved from rock salt, 655 m (2,150 ft) below the earth's surface. The nature of the salt is such that after a storage room has been filled, the salt will slowly fill the remaining spaces, thus isolating the waste for thousands of years.

Environmental Program Information

It is DOE's policy to conduct its operations at WIPP in compliance with all applicable environmental laws and regulations, and to safeguard the integrity of the southeastern New Mexico environment. This is accomplished through radiological and nonradiological environmental monitoring programs and land management programs, which include wildlife monitoring and the WIPP Raptor Program. The purpose of these programs is to collect data needed to detect and quantify possible impacts WIPP may have on the surrounding environment and to provide technical support to DOE's Carlsbad Area Office in the fields of environmental science and land management.

Environmental activities at WIPP generally fall into four categories: collecting environmental samples and analyzing them for a variety of contaminants, preparing and publishing documents showing compliance with federal and state regulations, evaluating whether WIPP activities cause any environmental impacts, and taking corrective action when an adverse effect on the environment is identified.

WIPP's Environmental Monitoring Plan outlines the programs that monitor the environment on, and immediately surrounding, the WIPP site. It discusses major environmental monitoring and surveillance activities at WIPP and WIPP's quality assurance/quality control program as it relates to environmental monitoring.

WIPP's effluent monitoring and environmental surveillance programs are designed to determine adequate protection of the public and the environment during DOE operations, and to ensure that operations comply with DOE and other applicable federal and state radiation standards and requirements. The Environmental Monitoring Program monitors the pathways that radionuclides and other contaminants could take to reach the environment surrounding WIPP. Pathways monitored include air, ground water, surface water, soils, sediments, vegetation, and game animals. In addition, ground-water quality and environmental health are also monitored. The goal of the program is to determine if the local ecosystem has been impacted during the predisposal and disposal phases of WIPP, and, if so, to evaluate the severity, geographic extent, and environmental significance of those impacts. The Environmental Monitoring Program is conducted in compliance with DOE Orders 5400.1 and 5400.5.

Southeastern New Mexico is home to an abundant array of wildlife. Wildlife species are monitored on the WIPP site to document any population changes that may occur as a result of WIPP activities. Species of special concern, including federally-listed threatened and endangered species, receive special consideration when planning WIPP activities that may impact wildlife habitat.

WIPP's Land Management Plan was created in accordance with the WIPP Land Withdrawal Act of 1992. This plan identifies resource values, promotes multiple-use management, and identifies long-term goals for the management of WIPP lands. In accordance with its Land Management Plan, WIPP follows a land reclamation program and a long-range reclamation plan. In 1999, reclamation on the Site Preliminary Design and Validation salt pile was initiated. WIPP also conducts oil and gas surveillances in the region surrounding the WIPP site to identify new activities associated with oil and gas exploration and production. In 1999, WIPP surveillance teams conducted 224 oil and gas surveillances in addition to routine bimonthly surveillances.

Environmental Compliance

WIPP is required to comply with all applicable federal and state laws and DOE orders. In 1999, WIPP maintained compliance with these laws and DOE orders.

Comprehensive Environmental Response, Compensation, and Liability Act

The Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) establishes a comprehensive federal strategy for responding to, and establishing liability for, releases of hazardous substances from a facility to the environment. No release sites have been identified at WIPP that would require cleanup under provisions of CERCLA.

Federal Acquisition, Recycling, and Pollution Prevention

In 1995, WIPP adopted a systematic and cost-effective affirmative procurement plan for the promotion and procurement of products containing recovered materials. Affirmative procurement is designed to "close the loop" in the waste minimization recycling process by supporting the market for materials collected through recycling and salvage operations. In 1999, WID purchased 98 percent of items required by the Environmental Protection Agency (EPA) through its affirmative procurement program.

WIPP continued its recycling program in 1999. Increases of 100 to 300 percent above 1998 levels were realized for most recycled materials. In addition, a Pollution Prevention Opportunity Assessment was performed to address concerns of using an industrial cleaner containing a known carcinogenic compound, and process changes were made to reduce the leaded brine waste stream by 50 percent.

Resource Conservation and Recovery Act

The Resource Conservation and Recovery Act (RCRA) ensures that hazardous wastes are managed and disposed of in ways that protect human health and the environment. WIPP is subject to permitting requirements under RCRA and the New Mexico Hazardous Waste Act. Non-mixed TRU radioactive waste shipments began arriving at WIPP on March 26, 1999. Shipments were postponed after November 22, 1999, to address requirements of the Waste Isolation Pilot Plant Hazardous Waste Permit, which was issued on October 27, 1999, and went into effect on November 26, 1999.

WIPP is in compliance with permit reporting requirements. As required, a notice was sent on December 8, 1999, to inform individuals on the WIPP mailing list that DOE had established three repositories for information associated with corrective action activities at WIPP.

Currently, WIPP personnel are preparing a WIPP Sampling and Analysis Plan for Solid Waste Management Units and Areas of Concern to comply with the RCRA permit. The Sampling and Analysis Plan has two objectives: to define the extent of concentrations of hazardous constituents that exceed background metal concentrations in soil at specific Solid Waste Management Units, and to perform a release assessment at specific Areas of Concern to determine if hazardous constituents are present above background concentrations.

National Environmental Policy Act

The National Environmental Policy Act (NEPA) requires the federal government to use all practicable means to consider potential environmental impacts of proposed federal projects as part of the decision-making process. NEPA dictates the public shall be allowed to review and comment on proposed projects that have the potential to significantly affect the environment. NEPA also directs the federal government to use all practicable means to improve and coordinate federal plans, functions, programs, and resources relating to human health and the environment.

Title 10 CFR § 1021.331 requires that, following completion of each Environmental Impact Statement and its associated Record of Decision (ROD), DOE shall prepare a mitigation action plan that addresses mitigation commitments expressed in the ROD. DOE Order 451.1A requires DOE facilities to track and annually report progress in implementing a commitment for environmental impact mitigation. The *1998 Annual Mitigation Report for the Waste Isolation Pilot Plant* was issued on June 28, 1999.

Clean Air Act

The Clean Air Act provides for the preservation, protection, and enhancement of air quality. Under section 109 of the Clean Air Act, the EPA established the National Ambient Air Quality Standards for six "criteria" pollutants. The initial WIPP hazardous air pollutant (HAP) emission inventory was developed as a baseline document to calculate maximum potential hourly and annual emissions of both hazardous and criteria pollutants. The HAPs inventory is conducted biennially and compared to baseline data to identify trends and potential emissions problems. The biennial inventory scheduled for calendar year 1998 was postponed because conditions at the site were unchanged from the previous inventory. The next inventory will be conducted in 2000. Based on the current HAPs inventory, WIPP operations do not exceed the 10-ton-per-year emission limit for any individual pollutant or the 25-ton-per-year limit for any combination of pollutants.

Based on emission estimates generated in the HAPs inventory, the WIPP site is not required to obtain federal Clean Air Act permits. WIPP was required to obtain a New Mexico Air Quality Construction Permit for two primary backup diesel generators. During 1999, the generators were operated for approximately 31 of the 480 hours allowed by the permit. There were no malfunctions or abnormal conditions of operations that would cause a violation of the permit.

Title 40 CFR § 61 requires WIPP to notify the EPA of its anticipated start date not more than 60 days and not less than 30 days before the actual start-up date. This notification was made on February 23, 1999; the actual start-up date was March 26, 1999. In addition, EPA required notification of the actual date of initial start-up be made within 15 days of actual start-up. The 15-day notice of actual start-up was made on March 26, 1999.

Clean Water Act

Section 402 of the Clean Water Act established provisions for the issuance of permits for discharges into waters of the United States. WIPP has no pollutant discharges from point sources and is currently exempt from obtaining a National Pollutant Discharge Elimination System permit.

A permit for Storm Water Discharge Associated with Industrial Activity was issued in 1998. No sampling is required to demonstrate compliance with this permit unless a release occurs. Operational permit compliance activities are limited to quarterly inspections of retention basins, spill containment devices, reclamations sites, and site housekeeping practices. DOE submits quarterly discharge monitoring reports to the New Mexico Environment Department to demonstrate compliance with inspection, monitoring, and reporting requirements as identified in the *WIPP Sewage System Discharge Plan.*

Safe Drinking Water Act

The Safe Drinking Water Act provides the regulatory strategy for protecting public water supply systems and underground sources of drinking water. The WIPP water supply is categorized as a nontransient, noncommunity system for reporting and testing requirements. The water supply is sampled 10 times every three years for various chemical constituents. Samples were collected in July 1999 and the results were submitted to the New Mexico Environmental Department. All samples were below action levels as specified by New Mexico monitoring requirements for lead and copper in tap water. Bacterial samples were collected and reported monthly throughout 1999. All results were below Safe Drinking Water Act regulatory limits.

National Historic Preservation Act

The National Historic Preservation Act was enacted to protect the nation's cultural resources and establish the National Register of Historic Places. Federal agencies are required to ensure that historic and cultural properties are given proper consideration in the preparation of NEPA-related documents. No new archeological sites were discovered in 1999, nor were any WIPP-related activities initiated that required archeological investigation.

Hazardous Materials Transportation Act

The Hazardous Materials Transportation Act is one of the major transportation-related statues that affects WIPP operations. It provides for the safe transportation of hazardous materials, including radioactive materials. DOE orders establish packaging and transportation criteria and require DOE field offices to conduct their operations in accordance with all applicable international, federal, state, local, and tribal laws, rules, and regulations governing materials transportation. These DOE orders also require the development of a transportation plan and use of the DOE TRANSCOM (transportation and tracking communications) system to monitor shipments.

Packaging and Transporting Radioactive Materials

The WIPP Land Withdrawal Act requires TRU waste containers shipped to WIPP be transported using packages which have had the design certified by the Nuclear Regulatory Commission (NRC) and which have been determined by the NRC to satisfied its quality assurance requirements. Contact-handled TRU waste will be shipped in TRUPACT-II and HalfPACT containers.

Environmental Compliance Assessment Program

The Environmental Compliance Assessment Program plays a major role in the overall program for environmental protection activities at WIPP. The program was developed to determine if facility activities protect human health and the environment and if these activities are in compliance with applicable federal, state, and local requirements; with permit conditions and requirements; and with best management practices. During 1999, six environmental compliance assessments were conducted. Forty-six improvements were identified and implemented as a result of these assessments.

ISO 14000

ISO 14001 is the specific section of the ISO 14000 standard devoted to Environment Management Systems. The WID Environmental Management System (EMS) received third-party registration on August 5, 1997. Two third-party registration surveillance audits were conducted in 1999. One minor nonconformance was identified during the March audit and the Environmental Policy was revised to include the EMS voluntary programs such as VPP and ISMS. No findings or observations were identified during the second surveillance conducted in August.

Several actions have been taken to more effectively implement the ISO 14001 Standard at WIPP. An ISO 14001 Integration Team has been formed and WIPP's ISO 14001 program is being integrated with other Westinghouse government-owned, contractor-operated programs.

Pollution Prevention Committee

WIPP's Pollution Prevention Committee was formed in 1993. The committee celebrates Earth Day to promote awareness of waste minimization. In October 1999, Energy Month was celebrated by the committee with a display of solar powered equipment.

Environmental Training

Environmental training was provided to personnel associated with environmental operations at WIPP.

Environmental Radiological Program Information

Radionuclides present in the environment, whether naturally-occurring or from human-made sources, contribute to radiation doses to humans. Therefore, environmental monitoring around nuclear facilities is imperative for characterizing radiation conditions, and for detecting releases and determining their effects, should they occur. The WIPP Environmental Monitoring Program monitors air, surface and ground water, soils, and biota to characterize the radiation environment and to detect potential releases from WIPP activities.

Effluent Monitoring

If radionuclides are released into the environment from WIPP, they would first be detected in airborne effluents. Therefore, WIPP monitors airborne effluents from the facility at three locations. Station A samples underground exhaust air, Station B samples unfiltered underground exhaust air after HEPA filtration as well as unfiltered air during maintenance, and Station C samples air in the Waste Handling Building after HEPA filtration. Representative samples were composited each quarter and sampled for ^{241}Am, ^{238}Pu, and $^{239+240}$Pu. Americium-241 was detected in composites from at least one station in each of the last three quarters. However, no values were over the decision level activity which represents background activity.

Airborne Gross Alpha/Beta

Gross alpha and beta measurements in airborne particulates are used as screening techniques to provide timely information on levels of radioactivity in the environment around the WIPP site. Airborne particulate samples were collected from seven locations around WIPP. Samples were collected weekly.

Weekly gross alpha activity concentrations measured in 1999 varied throughout the year at each location. Results from all of the sampling stations varied similarly throughout the year, indicating they were responding to the same environmental conditions. Only one measurement appeared to be an outlier. Analysis of Variance indicated no statistically significant differences between sampling stations.

The annual mean gross alpha activity concentrations found at each location in 1998 and 1999 were compared to determine whether gross alpha in air particulates had increased since waste has been stored at WIPP. A student's t-test was performed to determine if concentrations found in 1999 were statistically different from concentrations found in 1998 at each location. The concentrations were not found to be significantly different at any location.

In 1999, the weekly gross beta concentrations varied over almost an order of magnitude at each location. However, the annual concentrations of gross beta activities found at all locations were similar. The annual mean gross beta activity concentrations found at each location in 1999 were compared with those from 1998. No significant difference was found between years at any of the locations.

One duplicate sample was collected at a different location every quarter by rotating a portable sampler from one location to another. The samples were collected by two samplers in identical conditions at all four locations. Relative Error Ratios (RFR) were less than one in 96 percent of the weekly gross alpha and beta measurements, which indicates a good agreement between duplicates.

Airborne Particulates

The major pathways for the intake of radioactive materials in the human body are from the inhalation of dust particles and the ingestion of food and drinking water. Plutonium, the major constituent of TRU waste stored at WIPP, is mostly in an insoluble form. The uptake of insoluble materials through ingestion is very poor; therefore, inhalation is the major pathway for the intake of such radioactive materials. Accordingly, plutonium and other radionuclides of interest were determined in air particulate samples around WIPP.

Uranium-233+234 was detected in 64 percent of the samples, and in at least one sample from every location. Uranium-233+234 concentrations were not significantly different between locations or quarters. The concentration of ^{235}U in air particulate samples was lower than the minimum detectable concentration (MDC) throughout 1999. Uranium-238 was detected in 27 of the 28 composite air filters. There were not statistically significant differences in concentrations between sampling locations, but there were significant quarterly differences, with the second quarter having the highest ^{238}U concentration. Uranium-233+234, ^{235}U, and ^{238}U are all found naturally in the environment. The concentration of ^{235}U in the environment is much lower than the concentrations of $^{233+234}$U and ^{238}U.

Plutonium-238 was detected in composited air filters for the third quarter from one location and for the fourth quarter from another location. Detection is questionable for the third quarter result. The concentration of ^{238}Pu was below the MDC in each of the 26 other quarterly composites and the annual mean for every sampling location, including those closest to WIPP. Thus, the fourth quarter detection by itself does not indicate plutonium contamination of the environment.

Plutonium-239+240 was detected in quarterly composited air filters from the fourth quarter at one location. The concentration of $^{239+240}$Pu was below the MDC in each of the 27 other quarterly composites and the annual mean for every sampling location. The one detection does not by itself indicate plutonium contamination of the environment. Concentrations of ^{241}Am, ^{40}K, ^{60}Co, ^{90}Sr, and ^{137}Cs in each quarterly composite, and in annual means, were all below their MDC at all seven locations.

Duplicate samples were analyzed to check for reproducibility of the data. Relative error ratios were calculated to determine if the results from the duplicate samplers agreed with those from the regular samplers. For all results except two, the RERs were less than one, indicating a good agreement between regular and duplicate samples.

Ground Water

Ground-water samples were collected twice in 1999 from seven wells around WIPP and were analyzed for gamma-emitting radionuclides, ^{90}Sr, uranium, plutonium, and americium. Isotopes of naturally-occurring uranium were detected in every well. The concentrations of $^{233+234}$U and ^{238}U were significantly different between wells, but no pattern related to WIPP activities could be determined. Uranium-235 did not differ between wells. The results for the concentrations of uranium isotopes in water samples collected in 1999 were compared with the results from 1998. There was no significant difference in concentrations of any uranium isotope between ground-water samples collected in 1998 and those collected in 1999.

Plutonium-238, $^{239+240}$Pu, and ^{241}Am were also analyzed. Plutonium-238 was detected in one sample from one well. However, the annual mean for ^{238}Pu levels for that well was below the detection limit for ^{238}Pu. There was no statistical difference among ^{238}Pu concentrations between wells or between 1998 and 1999. Plutonium-239+240 and ^{241}Am were nondetectable in all samples.

The results of measurements for ^{40}K, ^{60}Co, ^{90}Sr, and ^{137}Cs were only reported by the laboratory for autumn sampling. Strontium-90 was detected in one well. All other concentrations of all four radionuclides were below the MDC.

Surface Water

Surface water samples were collected once from 12 locations around WIPP in 1999. In two cases where a surface water sampling location was dry, sediment at the location was collected instead. Uranium-238 was detected in surface water at every sampling location and ^{235}U was detected in 42 percent of the sampling locations. Uranium-233+234 was detected in 83 percent of the samples. There were no significant differences between concentrations of uranium isotopes between 1998 and 1999. Differences among sampling locations were detected for each uranium isotope. Large spatial variations in uranium concentrations in surface water are expected because of the different characteristics of the water bodies and the underlying sediments.

Plutonium-238, $^{239+240}$Pu, and ^{241}Am were also measured. Measured concentrations for all of these radionuclides were below the MDC. Additionally, no ^{40}K, ^{60}Co, ^{90}Sr, and ^{137}Cs were found in surface waters in 1999. A duplicate sample was collected at one sampling location. The results for uranium isotopes were compared between the original and the duplicate sample. The RER values were less than one, indicating no difference between samples.

Soil Samples

Soil samples were collected from six locations surrounding WIPP. Samples from each location were collected at three different depths. Measurements of radionuclides in depth profiles provide information about their vertical movements in soil systems.

Uranium-233+234 was detected in every soil sample in 1999 and ^{238}U was detected in all but one. Uranium-235 was detected in three of the 18 samples. The concentration of $^{233+234}U$ varied significantly between sampling locations. However, all measured concentrations fell within the range of natural concentrations of uranium found in soils throughout the world. There was no statistically significant difference in the concentrations of any uranium isotope with depth. Uranium-233+234 and ^{238}U varied significantly between 1998 and 1999. For both isotopes, the mean concentration was higher in 1998 than in 1999. All of these results suggest a natural variability consistent with the existence of natural uranium.

Plutonium-238, $^{239+240}Pu$, and ^{241}Am were also measured in soil samples. Neither ^{241}Am nor ^{238}Pu were detected in any samples. Plutonium-239+240 was detected in one sample at the intermediate depth. The absence of any other detectable Pu indicates this finding is likely not the result of releases from WIPP.

Potassium-40 was detected in every sample. This naturally-occurring radionuclide is ubiquitous in soils. The concentration of ^{40}K did not vary significantly between depths or between 1998 and 1999. However, there were significant differences seen between sampling locations. The range of concentrations observed are consistent with average natural ^{40}K concentrations around the world.

Neither ^{60}Co nor ^{90}Sr was detected in any soil sample. However, two human-made radionuclides, ^{58}Co and ^{65}Zn, were detected. These detections are unusual because both radionuclides have short half lives and were detected in subsurface soils. This combination makes it very likely these were anomalous results. Short-lived radionuclides detected on the surface could be explained as accidental releases; short-lived radionuclides at depth cannot easily be explained. This interpretation is supported by the large analytical uncertainties associated with both of these measurements.

Cesium-137 was detected in 10 of 18 soil samples. Although ^{137}Cs is a fission product, and a potential component of waste stored at WIPP, it is ubiquitous in soils because of global fallout from atmospheric nuclear weapons testing. There was no significant difference in the concentration of ^{137}Cs in soils around WIPP between 1998 and 1999, nor were there significant differences in ^{137}Cs concentrations between sampling locations or soil depths.

Sediments

Sediment samples were collected from 12 locations around the WIPP site, mostly from the same water bodies from which the surface water samples were collected. Uranium-233+234 and ^{238}U were detected in every sediment sample in 1999. Uranium-235 was detected in 42 percent of the samples. None of the uranium isotopes varied significantly between sampling locations or between 1998 and 1999. All concentrations of uranium were within the range of natural concentrations found in soils throughout the world.

Neither ^{238}Pu nor $^{239+240}Pu$ were detected in any sediment sample in 1999. Americium-241 was detected in seven of the 12 samples. The concentration of ^{241}Am was not significantly different between sampling locations or between 1998 and 1999. Strontium-90 was detected in one sample, and ^{137}Cs was detected in 42 percent of the sediment samples. Cobalt-60 was not detected in any of the samples. None of these radionuclides had sufficient detections to justify statistical comparisons between locations or years.

Potassium was detected in all sediment samples. Potassium-40 concentrations did not vary significantly between 1998 and 1999, but ^{40}K did vary significantly between locations. The concentration range measured in 1999 was similar to the average concentration of ^{40}K found in soils throughout the United States.

Duplicate samples were performed for all radionuclides in one sediment sample. The RER was less than one, indicating acceptable correspondence between the original and duplicate samples, for all radionuclides except for ^{238}U.

Biota

The concentration of radionuclides in plants is an important factor in estimating the intake of individual radionuclides by humans through ingestion. Therefore, rangeland vegetation samples were collected from the same six locations where soil samples were collected. Also collected were muscle tissues from three road-killed deer and a composite of several quail, both species commonly consumed by humans. Fish samples were taken from three different locations on the Pecos River. The whole fish and the muscle tissue from the deer and quail were analyzed for radionuclides.

Uranium-233+234 was detected in five of the six vegetation samples and ^{238}U was detected in all vegetation samples. Uranium-235 was not detected in any of the vegetation samples. The concentrations of $^{233+234}$U and ^{238}U did not vary significantly between locations, but they did vary significantly between 1998 and 1999. Average concentrations were higher in 1998 than 1999, which is consistent with what was seen in the soil. Concentrations of ^{241}Am, ^{238}Pu, and $^{239+240}$Pu were equal or less than the MDC in every sample. Potassium-40 was detected in five of the six vegetation samples and ^{90}Sr was detected in all vegetation samples. No other radionuclides of interest were detected in vegetation samples. Neither ^{40}K nor ^{90}Sr varied significantly between locations. Strontium-90 did not vary between 1998 and 1999; however, the concentration of ^{40}K in vegetation was significantly different between 1998 and 1999, with the 1999 mean being higher than the 1998 mean. As the primary source for potassium in plant tissues is the soil, the difference between soil results (no significant difference between 1998 and 1999) and plant results is difficult to explain. However, uptake of radionuclides and contamination by resuspension are highly species dependent and sometimes different between plants of the same species collected adjacent to one another. The difference may be related to a difference in the species mix sampled between years.

A duplicate analysis of one vegetation sample was performed. Concentrations of $^{233+234}$U, ^{238}U, ^{40}K, and ^{90}Sr were detected in the duplicate sample. The RER for ^{90}Sr was less than one, but the RERs for the remaining radionuclides were greater than one, indicating that laboratory results were not reproduceable.

Of radionuclides of interest, only the naturally-occurring radionuclide ^{40}K was detected in deer tissue. The mean concentration of ^{40}K was similar to that found in other mammals throughout the world. No radionuclides were found in the quail. Uranium-233+234 was detected in every fish sample and ^{238}U was detected in two of the three fish samples. Strontium-90 was also detected in two of the three samples and ^{40}K was detected in all fish. Americium-241, ^{238}Pu, and $^{239+240}$Pu were not detected in fish. Potassium-40 is present naturally in the environment, while ^{90}Sr is present in the environment worldwide as a result of fallout from above-ground nuclear weapons tests.

There were no statistically significant differences between concentrations of radionuclides in fish at any location. However, there was a significant difference between 1998 and 1999 for $^{233+234}$U and ^{40}K. Uranium-233+234 was higher in 1998 and ^{40}K was higher in 1999. This is attributable to natural variability because both radionuclides are naturally-occurring and are not major components of the waste stored at WIPP.

Environmental Nonradiological Program Information

Nonradiological environmental surveillance programs at WIPP include land management programs (including reclamation of disturbed lands, oil and gas surveillance, and wildlife population monitoring) and meteorological monitoring. In addition to nonradiological environmental surveillance programs, volatile organic compounds (VOCs) were monitored to comply with provisions of WIPP's hazardous waste permit, and liquid effluent monitoring was conducted in accordance to *WIPP Sewage System Discharge Plan* criteria.

The principal functions of the WIPP nonradiological environmental surveillance program are to:

- assess the impacts of WIPP construction and operations activities on the surrounding ecosystem;
- monitor ecological conditions in the Los Medaños region;
- investigate unusual or unexpected elements in the ecological databases;
- provide environmental data which are important to the mission of the WIPP project, but which have not or will not be acquired by other programs; and
- comply with applicable commitments identified with existing agreements.

WIPP Raptor Program

The WIPP Raptor Program was established in the early 1990s to monitor and protect raptors on the WIPP site, and to educate site workers and the public about these birds. The program presently serves four functions: wildlife monitoring, scientific research, community outreach, and interagency cooperation. In 1999, research continued on long-term studies of productivity and population demographics of the raptor community in and around WIPP. One study specifically targeted the behavioral ecology of the Harris' hawk, while another investigated breeding activity and nesting behavior of Swainson's hawks. In addition to ongoing studies, a pilot study was initiated in 1999 to evaluate methods for observing Swainson's hawks at the nest.

Meteorology

The annual precipitation at WIPP for 1999 was 200 mm (7.8 in). While precipitation in 1999 was greater than 1998, the total precipitation during 1999 was still below average. The mean annual temperature at WIPP was 18°C (64°F). Winds near WIPP blew predominantly from the southeast during 1999.

Volatile Organic Compound Monitoring

The volatile organic compound monitoring program is designed to measure VOC concentrations attributable to hazardous waste disposal units (panels) which are either open and are in the process of being filled or which are full and have been closed. Nine target compounds, which contribute approximately 99 percent of the calculated human health risks from RCRA constituents, are monitored. Sampling for target compounds is done at two air monitoring stations. One station monitors air found in the mine before it has passed through the panels containing the waste, while the other station monitors air that has passed through the waste panels. Differences measured between the two stations represent VOC contributions from the waste panels.

In 1999, only three (chlorobenzene, methylene chloride, and toluene) of the nine target compounds were measured above the detection limit. None of these compounds were found at an average concentration greater than 0.06 percent of the concentration of concern as listed in WIPP's hazardous waste permit. For each compound, 88 sample pairs (the difference between the first and second sampler) were compared. Positive sample pair differences were found in 12 of the 88 sample pairs for methylene chloride, 29 of 88 sample pairs for toluene, and one of 88 sample pairs for chlorobenzene, indicating there were differences in concentrations of these compounds between air samples collected before and after the waste panels.

Seismic Activity

Locations of 120 seismic events within 300 km (186 mi) of WIPP were recorded in 1999. The strongest recorded event (magnitude 4.0) was located about 80 km (50 mi) west-northwest of WIPP. These seismic events had no effect on WIPP structures.

Liquid Effluent Monitoring

The WIPP sewage lagoon system is a zero-discharge facility. The entire facility is lined with 30-mil synthetic liners and is designed to dispose of domestic sewage as well as site-generated brine waters. The facility is operated under the *WIPP Sewage System Discharge Plan* and is managed in accordance with EPA sewage sludge regulations, New Mexico Solid Waste Management Regulations, New Mexico Water Quality Control Regulations, and applicable WIPP controlled procedures.

Ground-water Monitoring

Current ground-water monitoring activities at WIPP are outlined in the *Groundwater Surveillance Program Plan*. The objectives of the WIPP Ground-water Monitoring Program are to:

- determine the physical and chemical characteristics of ground water;
- maintain surveillance of ground-water levels surrounding the WIPP facility, both before and throughout the operational lifetime of the facility;
- document and identify effects, if any, of WIPP operations on ground-water parameters; and
- fulfill the requirements of the RCRA Part B Permit Application and DOE Order 5400.1.

Data obtained by the WIPP Ground-water Monitoring Program supports two major programs at WIPP: (1) the RCRA Detection Monitoring Program, and (2) performance assessments supporting the Compliance Certification Application.

Ground-water monitoring activities during 1999 included ground-water quality sampling and ground-water level surveillance. Ground-water quality data were gathered from six wells in the Culebra member of the Rustler Formation and one well in the Dewey Lake Formation. Field analyses for Eh (Intensity Factor: an indicator of oxidation or reduction of chemical species), specific gravity, specific conductance, acidity or alkalinity, chloride, divalent cations, and total iron were performed on a periodic basis during serial sampling.

Because no hazardous wastes were shipped to WIPP before or during 1999, the results of ground-water sampling from 1999 and all previous sampling will be used to calculate baseline data for ground-water quality for the New Mexico Environmental Department Hazardous Waste Permit.

Ground-water surface elevations in the vicinity of WIPP may be influenced by site activities, such as pumping tests for site characterization, water quality sampling, or shaft sealing. In October 1988, WIPP was tasked with conducting a Ground-water Level Surveillance Program. Ground-water surface elevation data were gathered from 70 well bores, five of which were equipped with production-inflated packers to allow ground-water level surveillance of more than one producing zone through the same well bore. These well bores were used to perform surveillance of eight water-bearing zones in the WIPP region. The two zones of primary interest were the Culebra and Magenta members of the Rustler Formation. Ground-water elevation measurements in the Culebra member indicated the generalized directional flow of ground water was north to south in the vicinity of WIPP.

Regional ground-water levels taken in Culebra observation wells with four or more data points for the year showed increasing trends in water levels in 49 wells and decreasing trends in nine wells. Total fluctuations of more than 0.6 m (2 ft) in ground-water levels occurred in six wells completed to the Culebra. The fluctuations in three of these wells may have been influenced by ground-water sampling activities. Two wells experienced water-level fluctuations due to maintenance activities. The water level in one well continued a rising trend, of unknown cause, dating back to its completion in 1977.

Ground-water modeling efforts for 1999 developed a particle-based flow simulation, estimating the minimum travel time from the center of WIPP to the farthest boundary to be about 880 years. To date, there is no indication

WIPP operations have had a measurable impact on either the level or the quality of ground water underlying WIPP.

Radiological Dose Assessment

The potential radiation dose to members of the public from WIPP operations was calculated to demonstrate compliance with federal regulations and DOE's policies and objectives of keeping this dose as low as possible.

Dose Limits

For more than 50 years, extensive research has been conducted on the effects of radiation on humans and the environment. Much of this research used standard epidemiological and toxicological approaches to characterize the response of populations and individuals to high radiation doses. From this, a good understanding of the risks associated with high radiation doses was achieved. However, there is still uncertainty as to what risks are incurred from low radiation dose and dose rates, so models are used to predict these risks.

Regulatory dose limits are set well below where measurable health effects have been observed. Environmental radiation protection standards for the management and disposal of TRU radioactive wastes set limits on the total radiation dose to members of the public at 0.25 mSv/y (25 mrem/y) to the whole body and 0.75 mSv/y (75 mrem/y) to any critical organ. National standards for emissions of radionuclides from DOE facilities state that the maximum dose to any member of the public from air emissions must be no greater than 0.1 mSv/y (10 mrem/y). The Safe Drinking Water Act states that average annual concentrations of beta- and gamma-emitting human-made radionuclides in drinking water shall not result in a dose greater than 0.04 mSv/y (4 mrem/y). It is important to note that all of these dose limits are set for doses due to radionuclides released to the environment from DOE operations. They do not include, but are limits in addition to, doses from natural background radiation or from medical procedures.

Background Radiation

Radiation is a naturally-occurring phenomenon that has been in the environment since the beginning of time. There are several sources of natural radiation: cosmic and cosmogenic radiation (from outer space and the earth's atmosphere), terrestrial radiation (from the earth's crust), and internal radiation (naturally-occurring radiation in our bodies). In addition to natural radioactivity, small amounts of radioactivity from the 1986 Chernobyl nuclear accident and above-ground nuclear weapons tests that occurred from 1945 to 1980 are also present in the environment. Together, these sources of radiation are called "background" radiation. Every human is constantly exposed to background radiation. Exposure to radioactivity from weapons testing fallout is quite small compared to natural radioactivity and continually gets smaller as radionuclides decay. The average annual dose received by a member of the public from naturally-occurring radionuclides is about 3 mSv (300 mrem).

Dose from Air Emissions

The National Emission Standards for Hazardous Air Pollutants issued by the EPA set limits for doses due to radionuclide emissions to air. To determine the potential radiation dose received by members of the public from WIPP, WID used the computer model CAP88-PC, version 2.0. CAP88 dose calculations are based on the assumption that exposed persons remain at home during the entire year and all vegetables, milk, and meat consumed are home produced. Thus, this dose calculation is a maximum potential dose which encompasses dose from inhalation, submersion, deposition, and ingestion of air emitted radionuclides.

For 1999, the CAP88 model predicted the highest dose to someone residing near WIPP to be at the Smith Ranch, approximately 4 km (2.5 mi) northwest of WIPP. Results showed the whole body dose potentially received by someone residing at this location to be about 2.2×10^{-8} mSv (2.2×10^{-6} mrem) per year. The critical organ dose was less than 3.9×10^{-7} mSv (3.9×10^{-5} mrem) per year. This potential whole body dose is $2.2x10^{-5}$ percent of the whole body dose limits of 0.1 mSv (10 mrem) per year specified in 40 CFR § 61.92. The dose to a hypothetical person residing year-round at the WIPP fence line was estimated to be $3.1x10^{-7}$ mSv ($3.1x10^{-5}$ mrem) per year whole body and $5.3x10^{-6}$ mSv ($5.3x10^{-4}$ mrem) per year to the critical organ.

Total Potential Dose from WIPP Operations

The potential dose to an individual from the ingestion of WIPP-related radionuclides transported in water is estimated to be nonexistent. Drinking water for communities near WIPP comes from ground-water sources which are not expected to be affected by potential WIPP contaminants. Ground-water and surface water samples collected around WIPP during 1999 did not contain radionuclide concentrations different from those in samples collected prior to WIPP receiving waste.

Game animals sampled during 1999 were mule deer, quail, and fish. No radionuclides were detected in quail and those detected in deer and fish were not different from background levels measured prior to commencement of waste shipments to WIPP. Therefore, no dose from WIPP-related radionuclides is estimated to have been received by any individual from this pathway during 1999.

The only pathway for which a dose could be estimated was that of air emissions. Air emissions from WIPP were not considered above background ambient air levels. Estimated concentrations of radionuclides in air emissions accounted for the calculable dose from WIPP operations during 1999. The total dose from the air pathway (see "Dose from Air Emissions," above), was $8.8x10^{-6}$ percent of the whole body dose limits of 0.25 mSv (25 mrem) per year from all sources and $5.2x10^{-5}$ percent of the dose limit of 0.75 mSv (75 mrem) per year to the critical organ for all sources (40 CFR § 191.03). The dose to a hypothetical person residing year-round at the WIPP fence line was estimated to be $1.2x10^{-4}$ percent of the whole body dose limit of 0.25 mSv (25 mrem) per year from all sources and $7.1x10^{-4}$ percent of the dose limit of 0.75 mSv (75 mrem) to the critical organ from all sources.

Dose to non-human Biota

DOE Order 5400.5 lists the environmental radiation protection requirements that WIPP must meet to protect aquatic animals. In addition, dose limits below which no deleterious effects on populations of aquatic and terrestrial organisms have been observed have been discussed by the National Counil on Radiation Protection and Measurements and the International Atomic Energy Agency. Those dose limits are:

- Aquatic Animals 10 mGy/d (1 rad/d)
- Terrestrial Plants 10 mGy/d (1 rad/d)
- Terrestrial Animals 1 mGy/d (0.1 rad/d)

DOE requires discussion of radiation doses to non-human biota in the Annual Site Environmental Report using the Interim Technical Standard, DOE-STD-XXXX-00, *A Graded Approach for Evaluating Radiation Doses to Aquatic and Terrestrial Biota*. The Interim Technical Standard uses a multi-phase approach, including an initial screening phase with conservative assumptions. In the initial screen, maximum concentrations of radionuclides detected in soil, sediment, and water during environmental monitoring are divided by Biota Concentration Guides (BCG), concentrations of radioactivity in the sampled media which would provide a radiation dose equal to the appropriate limits. These fractions are summed for each organism and, if the sum of fractions is less than 1, the site is deemed to have passed the screen and no further action is required. This screening evaluation is intended to provide a very conservative evaluation of whether the site is in compliance with the recommended limits.

This guidance was used to screen radionucide concentrations observed around WIPP during 1999. The sum of fractions was less than one for all media, demonstrating compliance with the proposed rule. Radiation in the environment surrounding WIPP does not have a deleterious effect on populations of plants and animals.

Quality Assurance

The fundamental objective of a quality assurance (QA) program is to ensure high-quality measurements are produced and reported from the analytical laboratory. The defensibility of data generated by laboratories must be based on sound scientific principles, method evaluations, and data verification and validation. Thermo NuTech, of Albuquerque, NM; Air Toxics, Ltd. of Folsom, CA; and Trace Analysis, of Lubbock, TX, were the contract laboratories that performed the radiological and nonradiological analyses for WIPP environmental samples. The WIPP laboratory performed the gross alpha and gross beta analyses on weekly air dust samples.

The WID Environmental Monitoring Section performed assessments and audits to ensure the quality of the systems, processes, and deliverables was maintained or improved in 1999. Along with these regulatory requirements, the Environmental Monitoring Section also implements DOE Order 414.1, *Quality Assurance.* The parameters for performance evaluations are completeness, reproducibility, accuracy, comparability, and representativeness.

Completeness

The completeness parameter was calculated as the ratio of the number of valid results to the total number of samples collected and analyzed. The Environmental Monitoring Program's overall data quality objective of 98 percent completeness for environmental samples was achieved during 1999.

Reproducibility

The reproducibility of the measurements was validated through analysis of duplicate samples. A low-volume air sampler was rotated in each quarter from location to location and sampled along with routine samples. The duplicate samples for other matrices were collected at the same time, same place, and under similar conditions as routine samples. These samples were analyzed in the same analytical batch and/or sample delivery group using similar methods for radiochemical separations and counting as original samples. The RER of the duplicate air samples was calculated. Of the 98 RER values calculated for duplicate air samplers, 95 had RER values equal or less than one, which are considered to demonstrate reproducibility.

Accuracy and Comparability

The accuracy of the analyses were assured/controlled by using National Institute of Standards and Technology-traceable standards for instrument calibration. Internal quality control is performed by using spiked laboratory control samples. Intercomparisons were performed with the DOE Environmental Measurements Laboratory to ensure the reliability of radiochemical separation methods and counting instruments. Accuracy is expressed in terms of percent bias.

Thermo NuTech participated in this program. The laboratory's percent bias in evaluating air filters was not acceptable for ^{54}Mn, ^{239}Pu, ^{90}Sr, and ^{238}U. The gross alpha and gross beta analyses for air filters were not acceptable.

The reported values for ^{214}Bi, ^{214}Pb, ^{212}Pb, ^{239}Pu, and ^{234}Th in the soil matrix were not acceptable. All the reported values for radionuclides in the vegetation samples were acceptable, and all but one of the reported values for radionuclides in the water samples were acceptable; the reported value for ^{234}U had a negative bias of 24.3 percent.

Thermo NuTech's failure of these laboratory intercomparisons is of concern. However, because of the low values being measured and the large uncertainties associated with them, this failure does not invalidate the conclusion that WIPP has not released radioactivity into the environment.

Environmental Resource Associates provides an interlaboratory assessment of the analysis for volatile organics. Air Toxics participated in this assessment and received a score of 100 percent and an overall assessment of "excellent." Environmental Resource Associates also provides an interlaboratory assessment of the analysis for water pollutants. Trace Analysis participated in this assessment and received a score of 80.8 percent and an overall assessment of "good."

Representativeness

The quality objective of representativeness was based on potential radiation exposure of the population through inhalation and ingestion. Samples of ambient air, surface water, sediment, ground water, and biota were collected from areas representative of potential pathways for intake.

The samples were collected using generally accepted methodologies for environmental sampling and approved procedures, ensuring they were representative of the media sampled. These samples were analyzed for natural radioactivity, fallout radioactivity from nuclear weapons tests, and other anthropogenic radionuclides. The reported concentrations at various locations were representative of the baseline information for radionuclides of interest at the WIPP facility.

Chapter 6
Ground-water Monitoring

Current ground-water monitoring activities at WIPP are outlined in the *Groundwater Surveillance Program Plan* (WID WP 02-1, Revision 5). The plan is a QA document that contains program plans for each of the activities performed by ground-water monitoring personnel. In addition, WIPP has detailed procedures for performing specific activities, such as pumping system installations, field parameter analyses and documentation, and QA records management. Ground-water monitoring activities are also defined in the EMP.

The objectives of the Ground-water Monitoring Program are to:

- determine the physical and chemical characteristics of ground water;
- maintain surveillance of ground-water levels surrounding the WIPP facility, both before and throughout the operational lifetime of the facility;
- document and identify effects, if any, of WIPP operations on ground-water parameters; and
- fulfill the requirements of the RCRA Part B Permit Application and DOE Order 5400.1.

The data obtained by the WIPP Ground-water Monitoring Program (formerly designated the WIPP Groundwater Quality Surveillance Program [WQSP]) supported two major programs at WIPP: (1) the RCRA Detection Monitoring Program supporting the RCRA Part B Permit Application in compliance with 40 CFR § 264 and 20 New Mexico Administrative Code (NMAC) 4.1, and (2) performance assessment supporting the Compliance Certification Application (DOE/CAO 96-2184) in compliance with 40 CFR § 191 and 40 CFR § 194. Each of these programs requires a unique set of analyses and data. Particular sample needs are defined by each program.

Background data were collected from 1995 through 1997 and reported in the *Waste Isolation Pilot Plant RCRA Background Groundwater Quality Baseline Report* (DOE/WIPP 98-2285). These background data will be compared to water quality data collected throughout the operational life of the facility.

Ground-water monitoring activities during 1999 included ground-water quality sampling and ground-water level surveillance. Ground-water quality data were gathered from six wells completed in the Culebra member of the Rustler Formation (wells WQSP-1 through WQSP-6) and one well completed in the Dewey Lake Formation (well WQSP-6A; Figure 6.1). Ground-water surface elevation data were gathered from 70 well bores, five of which were equipped with production-inflated packers to allow ground-water level surveillance of more than one producing zone through the same well bore (Figure 6.2).

6.1 Ground-water Quality Sampling

The RCRA Permit Module V requires ground-water quality sampling twice a year, from March through May (Round 8 for 1999) and, again, from September through November (Round 9 for 1999). Sampling for ground-water quality was performed at seven well sites during 1999 (Figure 6.1). The wells were serially sampled as soon as possible after the pump was turned on to better observe early chemical reactions to pumping. Field analysis for Eh (Intensity Factor: an indicator of oxidation or reduction of chemical species), specific gravity, specific conductance, acidity or alkalinity, chloride, divalent cations, and total iron were performed on a periodic basis during the serial sampling.

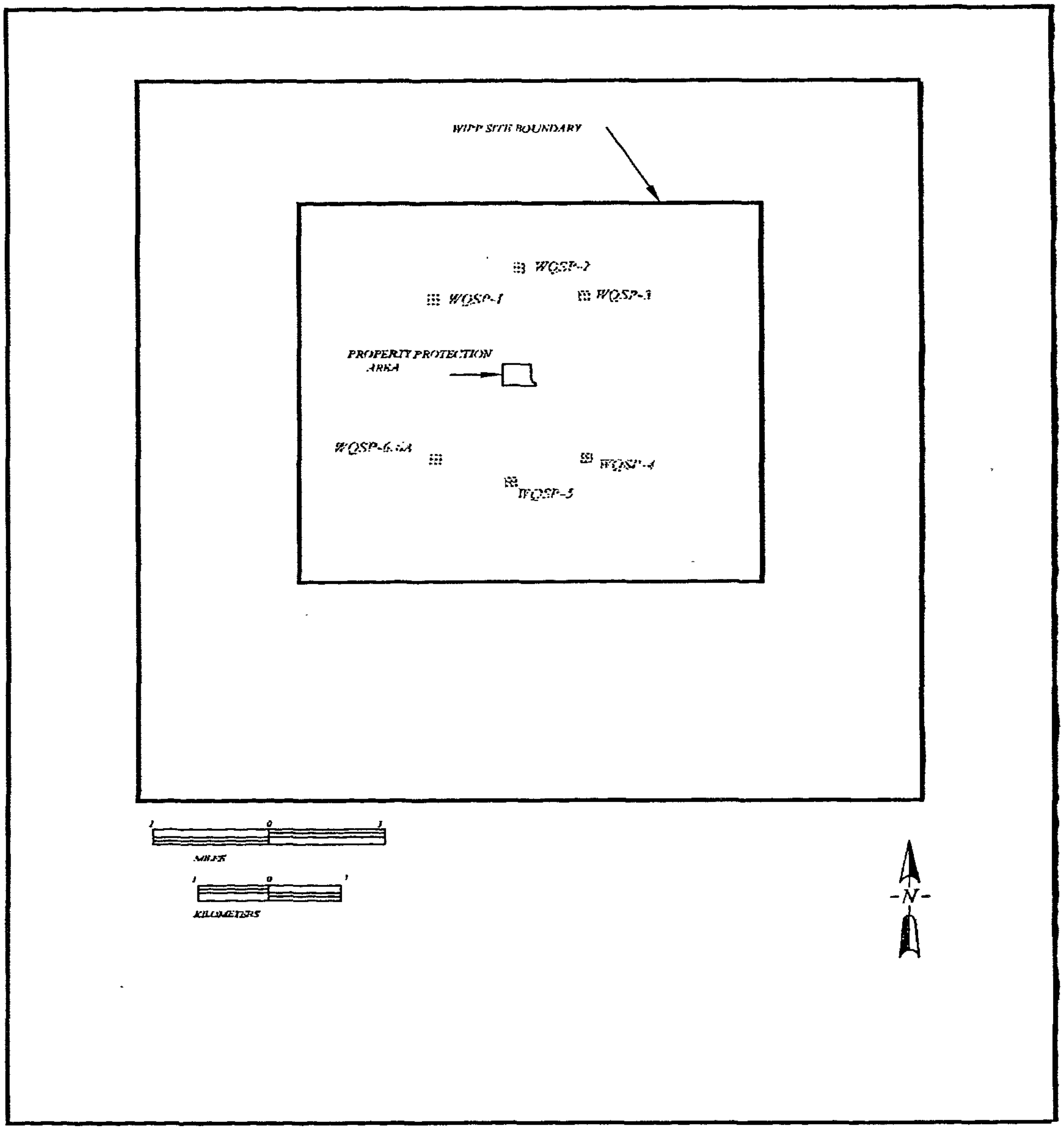


Figure 6.1 Water Quality Sampling Program Sample Wells

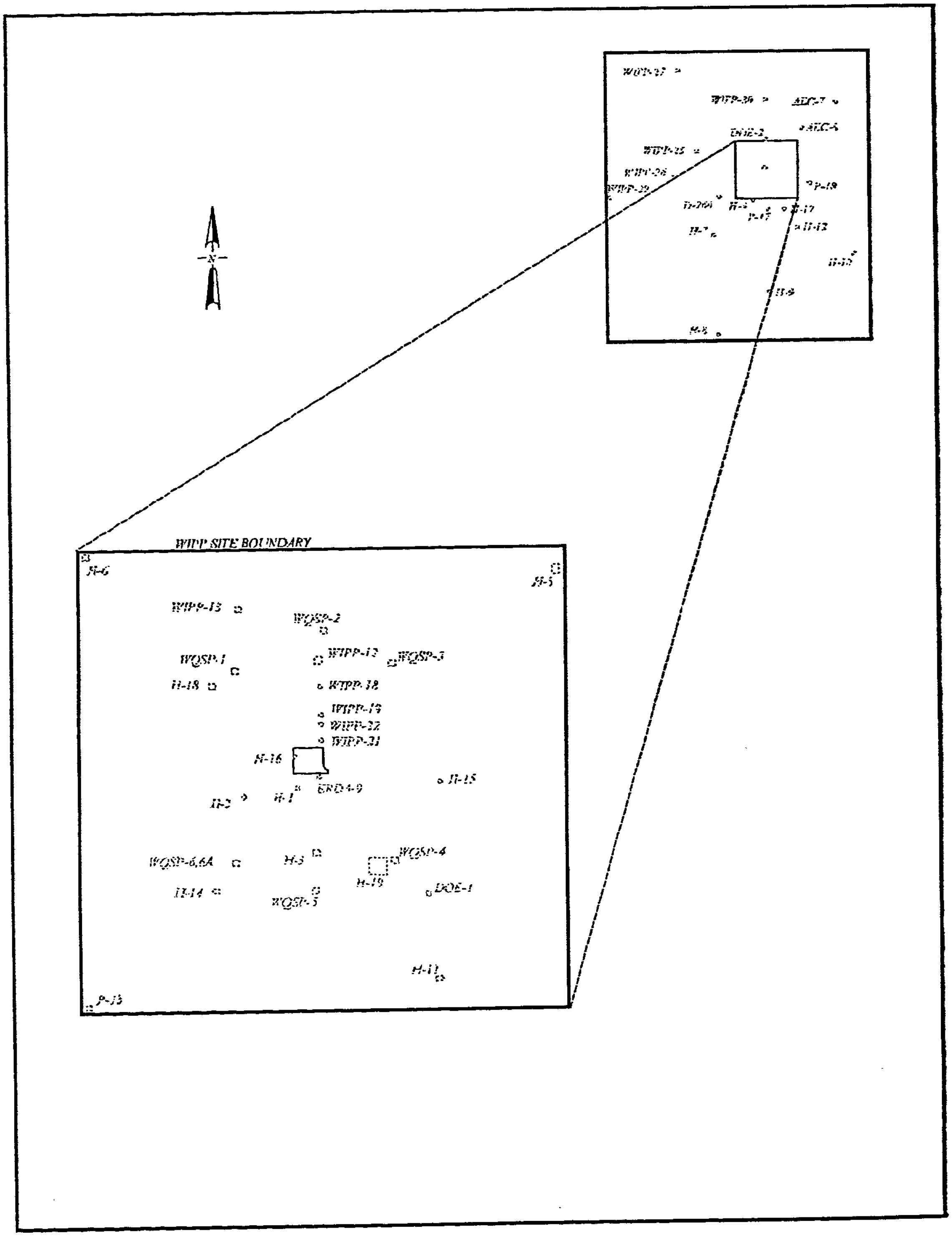


Figure 6.2 Ground-water Level Surveillance Wells

During 1999, ground-water surveillance activities removed approximately 37,340 L (9,864 gal) of water from the Culebra member of the Rustler Formation and 24,380 L (6,441 gal) from the Dewey Lake Formation. The quality of the Culebra water sampled near WIPP is naturally poor and not suitable for human consumption or for agricultural purposes. TDS concentrations measured in the Culebra ranged from less than 10,000 to 280,000 mg/L. The ground water of the Culebra is considered to be Class III water by EPA guidelines.

Water quality measurements performed in the Dewey Lake Formation indicate the waters are considerably better quality than the Culebra water. TDS values were below 10,000 mg/L. The water is suitable for livestock consumption, and classified as Class II water according to EPA guidance. Saturation of the Dewey Lake Formation in the area of WIPP is discontinuous. No hydrologic connection has been established that would indicate WIPP activities would have a potential impact on the Dewey Lake Formation.

The New Mexico Environmental Department (NMED) Hazardous Waste Permit, Attachment L, Section L-4a states "detection monitoring will start when the Permittees emplace waste . . . ." Because wastes were expected to be shipped to WIPP much sooner than the year 2000, it was expected that baselines would be established using only four samples from each well, per Hazardous Waste Permit, Module V, Section V.F.2. Because no hazardous wastes were received at WIPP before or during 1999, the results of the ground-water quality sampling for 1999 (rounds eight and nine), and all previous sampling rounds, will be used to calculate the baseline for the parameters and constituents listed in Table 6.1, per the NMED Hazardous Waste Permit Module V, Table V.D. Baseline calculations will also include data from the first sampling round of 2000 (round 10), the final sampling session before the first shipment of waste was received at WIPP. By including sampling rounds six through ten as part of the baseline data, the baseline population will more than double and consequently allow for more meaningful and robust statistical analyses. In addition, using a larger sample size to calculate baseline metrics will better address the issue of variability in results reported by different laboratories conducting the same analyses (see below).

Because of the highly variable transmissivity and density values within the Culebra, baseline ground-water quality was defined for each individual well. These values were calculated prior to the decision to include sampling rounds six through ten in baseline calculations, and are based only on earlier sampling rounds. These values will be re-computed when all baseline sampling is completed in 2000. Tables 6.2 through 6.8 summarize the results of analyses for each parameter or constituent for the two sampling sessions in 1999 (rounds eight and nine).

In these tables, either the 95th upper tolerance limit value (UTLV) or the 95th percentile value is presented for baseline data with concentrations that were well above the method detection limit prior to 1999. Both values represent the value beneath which 95 percent of the values in a population are expected to occur. UTLVs were calculated for data which exhibited a normal or a lognormal distribution. The 95th percentile was determined for data which were considered non-parametric; having neither a normal nor a lognormal distribution. Due to the large number of non-detectable concentrations of organic compounds, the limits for organic compounds were considered non-parametric and based on the method detection limit reported by the laboratory. These values will be re-computed when all baseline sampling is completed in 2000, and will be used in subsequent sampling rounds to evaluate for contamination of the ground-water wells.

Table 6.1 Analytical parameters for which ground water was analyzed.

CAS No.[1]	Parameter	EPA Method Number	CAS No.	Parameter	EPA Method Number
71-55-6	1,1,1-Trichloroethane	8260B	7727-37-9	Nitrate (as N)	300.0
79-34-5	1,1,2,2-Tetrachloroethane	8260B		Orthophosphate (as P)	365.2
79-00-5	1,1,2-Trichloroethane	8260B		pH	150.1
75-34-3	1,1-Dichloroethane	8260B		Specific conductance	120.1
75-35-4	1,1-Dichloroethylene	8260B		Sulfate	300.0
107-06-2	1,2-Dichloroethane	8260B		Total dissolved solids	160.1
56-23-5	Carbon tetrachloride	8260B		Total organic carbon	415.1
108-90-7	Chlorobenzene	8260B		Total organic halogen	9020B
67-66-3	Chloroform	8260B		Total phenols	420.1
540-59-0	*cis*-1,2-Dichloroethylene	8260B		Total suspended solids	160.2
78-93-3	Methyl ethyl ketone	8260B		Gross alpha	900
75-09-2	Methylene chloride	8260B		Gross beta	900
127-18-4	Tetrachloroethylene	8260B	7440-36-0	Antimony	6010B
108-88-3	Toluene	8260B	7440-38-2	Arsenic	6010B
79-01-6	Trichloroethylene	8260B	7440-39-3	Barium	6010B
75-69-4	Trichlorofluoromethane	8260B	7440-41-7	Beryllium	6010B
75-01-4	Vinyl chloride	8260B	7440-42-8	Boron	6010B
1330-20-7	Xylene	8260B	7440-43-9	Cadmium	6010B
95-50-1	1,2-Dichlorobenzene	8270C	7440-70-2	Calcium	6010B
106-46-7	1,4-Dichlorobenzene	8270C	7440-47-3	Chromium	6010B
51-28-5	2,4-Dinitrophenol	8270C	7440-48-4	Cobalt	6010B
121-14-2	2,4-Dinitrotoluene	8270C	7440-50-8	Copper	6010B
95-48-7	2-Methylphenol	8270C	7439-89-6	Iron	6010B
108-39-4/ 106-44-5	3-Methylphenol/ 4-Methylphenol	8270C	7439-92-1	Lead	6010B
			7439-93-2	Lithium	6010B
118-74-1	Hexachlorobenzene	8270C	7439-95-4	Magnesium	6010B
67-72-1	Hexachloroethane	8270C	7439-97-6	Mercury	7470A
98-95-3	Nitrobenzene	8270C	7440-02-0	Nickel	6010B
87-86-5	Pentachlorophenol	8270C	7440-09-7	Potassium	6010B
110-86-1	Pyridine	8270C	7782-49-2	Selenium	6010B
78-83-1	Isobutanol	8015B	7631-86-9	Silica	6010B
	Alkalinity	310.1	7440-22-4	Silver	6010B
7726-95-6	Bromide	300.0	7440-23-5	Sodium	6010B
7782-50-5	Chloride	300.0	7440-28-0	Thallium	6010B
	Density[2]		7440-31-5	Tin	6010B
	Fluoride	300.0	7440-62-2	Vanadium	6010B
	Iodide	345.1	7440-66-6	Zinc	6010B

[1] Chemical Abstract Service Registry Number
[2] Analysis method was ASTM (American Society for Testing and Materials) D854-92

As stated above, TDS, measured as filterable residue, of the Culebra Member in the WIPP area ranged from less than 10,000 to over 280,000 mg/L. High TDS samples require dilution prior to analysis. The dilution factors varied between sampling rounds and wells. The variable dilution factors resulted in method detection limits for organics and other constituents that were inconsistent and inconclusive: some concentrations reported as "nondetect" exceeded the maximum permissible contamination levels. For gross alpha and beta analyses the total aliquot size was much smaller than the normal aliquot for clean water, and ranged from 1 ml (0.033 oz) to 15 ml (0.507 oz). Consequently, the reported detection limits were very high. Three different contract laboratories used recommended EPA methods to perform the ground-water chemistry analyses. Due to the variability in dilution factors and sensitivity of instruments, the concentrations and method detection limits from different laboratories were also different.

The analytical results for detectable constituents are plotted as Time Trend Plots compared to the baseline established prior to 1999 (Figures 6.5 through 6.123). Because data from ground-water quality sampling rounds eight and nine are to be included in calculations to establish baseline conditions, summary accounts of comparisons for individual wells and analytes were not developed for 1999.

6.2 Ground-water Level Surveillance

Ground-water surface elevations in the vicinity of WIPP may be influenced by site activities, such as pumping tests for site characterization, water quality sampling, or shaft sealing. Other influences on ground-water surface elevations may be caused by natural ground-water level fluctuations and industrial influences from agriculture, mining, and resource exploration.

In October 1988, WIPP was tasked with conducting a Ground-water Level Surveillance Program. Seventy well bores were used to perform surveillance of eight water-bearing zones in the WIPP area (Figure 6.2). The two zones of primary interest were the Culebra and Magenta members of the Rustler Formation (see Figure 1.1). Sixty measurements were taken in the Culebra and nine in the Magenta. Three measurements each were taken in the Dewey Lake and Santa Rosa Formations. Two measurements were taken in the Rustler/Salado contact. One measurement each was taken in Bell Canyon, Forty-niner, and an unnamed lower member. In 1999, ground-water level measurements were taken monthly in at least one accessible well bore at each well site for each available formation. Redundant well bores at each well site were measured on a quarterly basis.

Four well bores (H-01 Culebra/Magenta, H-03d Dewey Lake/Forty-niner, H-16 Dewey Lake/unnamed lower member, and WIPP-25 Culebra/Magenta) were completed at multiple depths. By using packers, these bores may be monitored in more than one formation.

Ground-water elevation measurements in the Culebra member indicated the generalized directional flow of ground water was north to south in the vicinity of WIPP (Figure 6.3a). Modeling of flow patterns produced similar results (Figure 6.3b). Regional ground-water levels taken in Culebra observation wells with four or more data points for the year showed increasing trends in water levels in 49 wells and decreasing trends in nine wells.

Total fluctuations of more than 0.6 m (2 ft) in ground-water levels occurred in six wells completed to the Culebra. Three wells with fluctuations of more than 0.6 m (2 ft) (WQSP-2, WQSP-3, and WQSP-6) may have been influenced by ground-water sampling activities. Two wells (H-1 and Cabin Baby) experienced water-level fluctuations due to maintenance activities. Water level in P-18 continued a rising trend, of unknown cause, dating back to its completion in 1977.

Ground-water level data were transmitted on a monthly basis to the NMED, EEG, Sandia National Laboratories, CTAC, and technical subcontractors as requested by the CAO. A copy of the data was placed in the operating record for inspection by authorized agencies.

Ground-water modeling efforts for 1999, using a one percent porosity value, developed a particle-based flow simulation estimating the minimum travel time as 880 years from the center of WIPP to the boundary (Figure 6.4).

The interpretation of ground-water data collected in 1999 are similar to previous years. To date there is no indication WIPP operations have had a measurable and significant impact on either the level or the quality of ground water underlying WIPP.

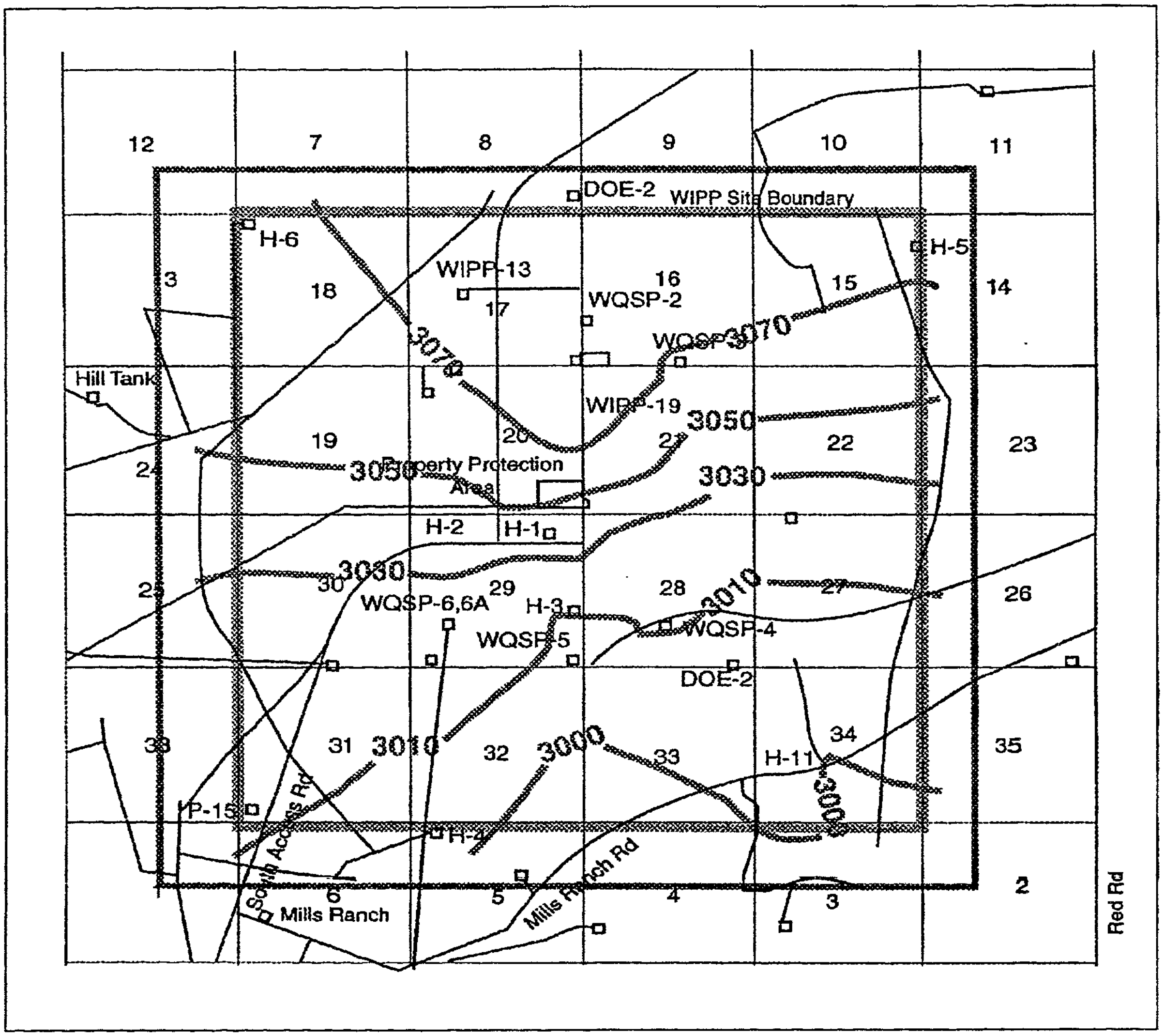


Figure 6.3a Measured Ground-water Potentiometric Surface (feet) in the Culebra Member of the Rustler Formation

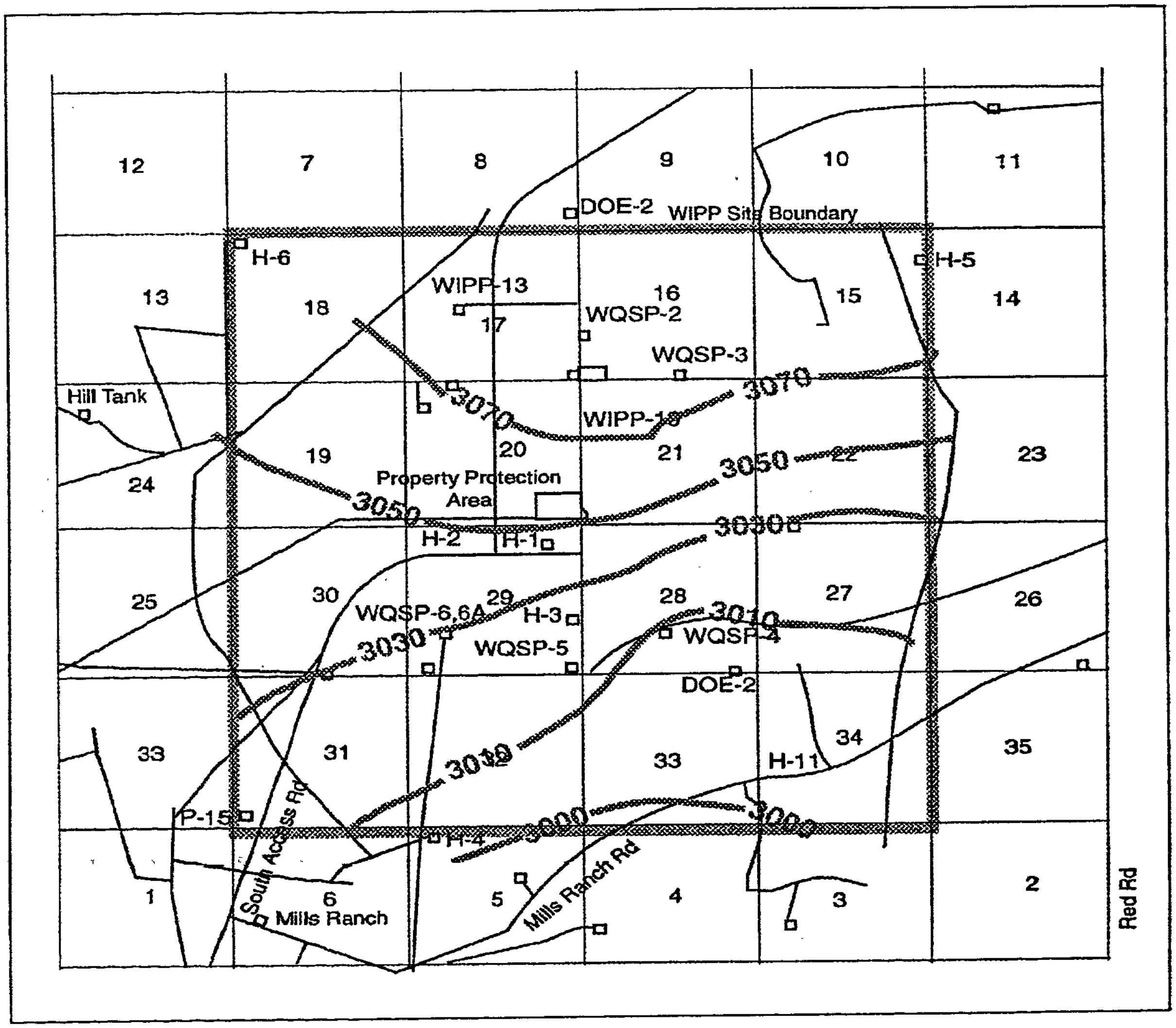


Figure 6.3b Modeled Ground-water Potentiometric Surface (feet) in the Culebra Member of the Rustler Formation

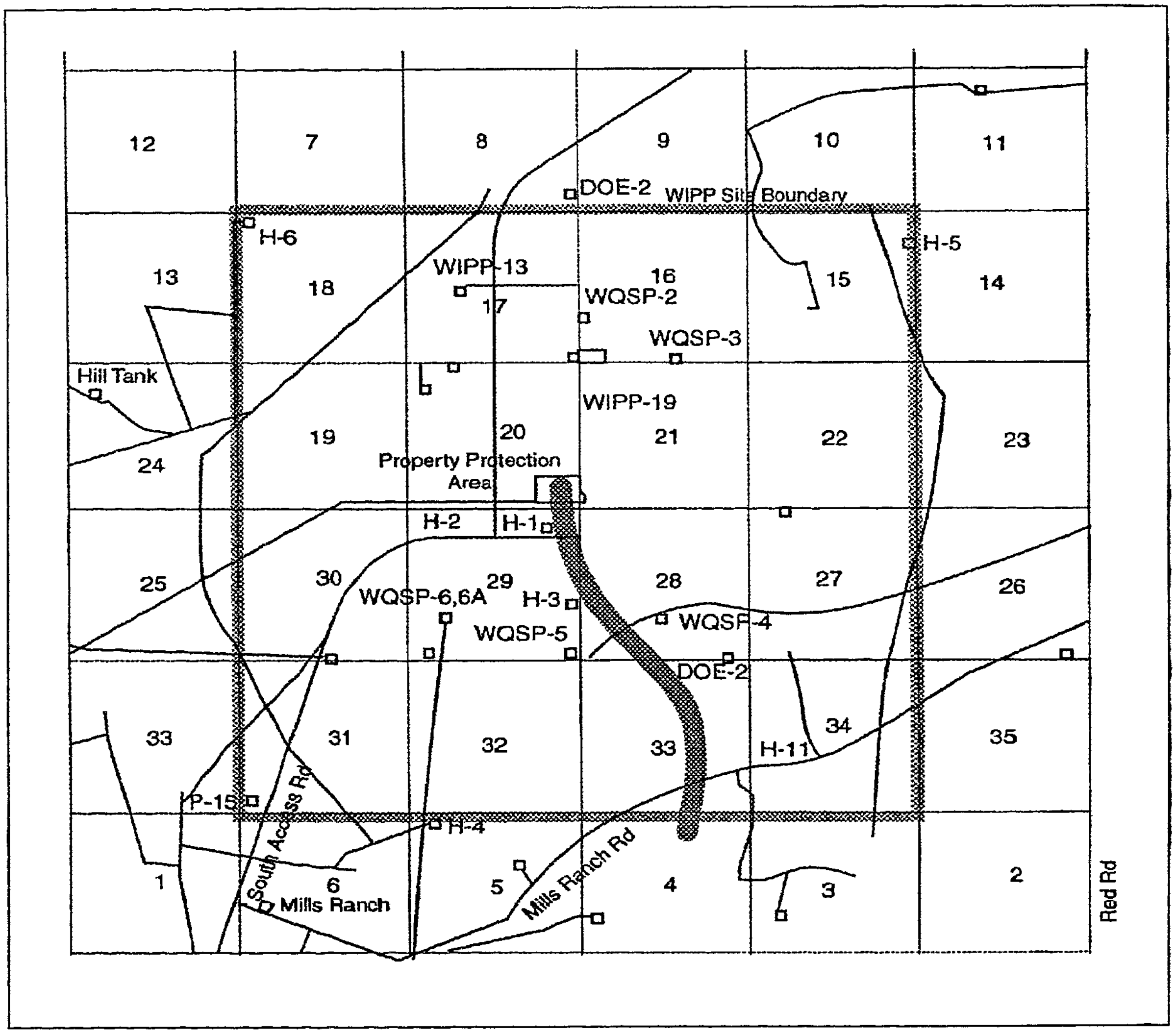


Figure 6.4 Modeled particle movement in ground-water flow in the Culebra Member of the Rustler Formation

Table 6.2 Analytical results for ground water sampled from well WQSP-1.

	Concentration							
	Round 8		Round 9			Reporting Limit		
Parameter	**Sample**	**Dup.**	**Sample**	**Dup.**	**Units**	**Round 8**	**Round 9**	**95th UTLV[1]**
1,1,1-Trichloroethane	<1	<1	<2	<2	□g/L	1	2	<RL[2]
1,1,2,2-Tetrachloroethane	<1	<1	<2	<2	□g/L	1	2	<RL
1,1,2-Trichloroethane	<1	<1	<2	<2	□g/L	1	2	<RL
1,1-Dichloroethane	NR[3]	NR	<2	<2	□g/L	NR	2	<RL
1,1-Dichloroethylene	<1	<1	<2	<2	□g/L	1	2	<RL
1,2-Dichloroethane	<1	<1	<2	<2	□g/L	1	2	<RL
Carbon tetrachloride	<1	<1	<2	<2	□g/L	1	2	<RL
Chlorobenzene	<1	<1	<2	<2	□g/L	1	2	<RL
Chloroform	<1	<1	<2	<2	□g/L	1	2	<RL
cis-1,2-Dichloroethylene	<1	<1	<2	<2	□g/L	<1	2	<RL
Methyl ethyl ketone	<50	<50	<10	<10	□g/L	50	10	<RL
Methylene chloride	<5	<5	<5	<5	□g/L	5	5	<RL
Tetrachloroethylene	<1	<1	<2	<2	□g/L	1	2	<RL
Toluene	<1	<1	<2	<2	□g/L	1	2	<RL
Trichloroethylene	<1	<1	<2	<2	□g/L	1	2	<RL
Trichlorofluoromethane	<1	<1	<2	<2	□g/L	1	2	<RL
Vinyl chloride	<1	<1	<2	<2	□g/L	1	2	<RL
Xylene	<1	<1	<2	<2	□g/L	1	2	<RL
1,2-Dichlorobenzene	<1	<1	<1	<1	□g/L	1	1	<RL
1,4-Dichlorobenzene	<1	<1	<1	<1	□g/L	1	1	<RL
2,4-Dinitrophenol	<1	<1	<1	<1	□g/L	1	1	<RL
2,4-Dinitrotoluene	<1	<1	<1	<1	□g/L	1	1	<RL
2-Methylphenol	<1	<1	<1	<1	□g/L	1	1	<RL
3-Methylphenol/ 4-Methylphenol	<1	<1	<1	<1	□g/L	1	1	<RL
Hexachlorobenzene	<1	<1	<1	<1	□g/L	1	1	<RL
Hexachloroethane	<1	<1	<1	<1	□g/L	1	1	<RL
Nitrobenzene	<1	<1	<1	<1	□g/L	1	1	<RL
Pentachlorophenol	<1	<1	<1	<1	□g/L	1	1	<RL
Pyridine	<1	<1	<1	<1	□g/L	1	1	<RL

Chapter 7
Radiological Dose Assessment

It is the policy of DOE ". . . to conduct its operations in an environmentally safe and sound manner. Protection of the environment and the public are responsibilities of paramount importance and concern to DOE" (DOE Order 5400.1). "It is also a DOE objective that potential exposures to members of the public be as far below the limits as is reasonably achievable. . ." (DOE Order 5400.5).

Chapter 4 of this report summarized the amount of radioactivity in various media sampled in the WIPP environment in 1999. It is the purpose of this chapter to summarize what those levels mean in regards to the potential dose from WIPP operations.

Specifically, this chapter summarizes:

- introductory information on human radiation dose limits and risks from radiation,
- the national average dose from naturally-occurring sources of radiation,
- the estimated dose from air emissions from WIPP,
- the total potential dose from WIPP operations, and
- potential doses to non-human biota from radioactivity measured near WIPP.

7.1 Introduction and Dose Limits

In this chapter, the term "dose" will refer to the committed effective dose equivalent unless another term is specifically stated. Dose was calculated by summing the committed dose equivalents to organs, each multiplied by a weighting factor proportional to each organ's sensitivity to radiation. Additional methods for calculating dose are discussed in the following sections on specific pathways.

For more than 50 years, extensive research has been conducted on the effects of radiation on humans and the environment. Much of this research used standard epidemiological and toxicological approaches to characterize the response of populations and individuals to high radiation doses. From this, a good understanding of the risks associated with high radiation doses was achieved. However, there is still uncertainty as to what risks are incurred from low radiation doses and dose rates. Because of the low rate of cancer incidence at low levels of radiation exposure, and the large sample sizes needed to study this relationship, risks due to low levels of radiation exposure are difficult to obtain; therefore, models have been used to predict risks from low radiation doses (Figure 7.1).

Regulatory dose limits are set well below levels where measurable health effects have been observed. Environmental radiation protection standards for the management and disposal of TRU radioactive wastes set limits on the total radiation dose to members of the public at 0.25 mSv/y (25 mrem/y) to the whole body and 0.75 mSv/y (75 mrem/y) to any critical organ (40 CFR § 191.03). National standards for emissions of radionuclides from DOE facilities state that the maximum dose to any member of the public from air emissions must be no greater than 0.1 mSv/y (10 mrem/y) (40 CFR § 61.92). The Safe Drinking Water Act (40 CFR § 141.16) states that average annual concentrations of beta- and gamma-emitting human-made radionuclides in drinking water shall not result in a dose greater than 0.04 mSv/y (4 mrem/y). It is important to note that all of these dose limits are set for radionuclides released to the environment from DOE operations. They do not include, but are limits in addition to, doses from natural background radiation or from medical procedures.

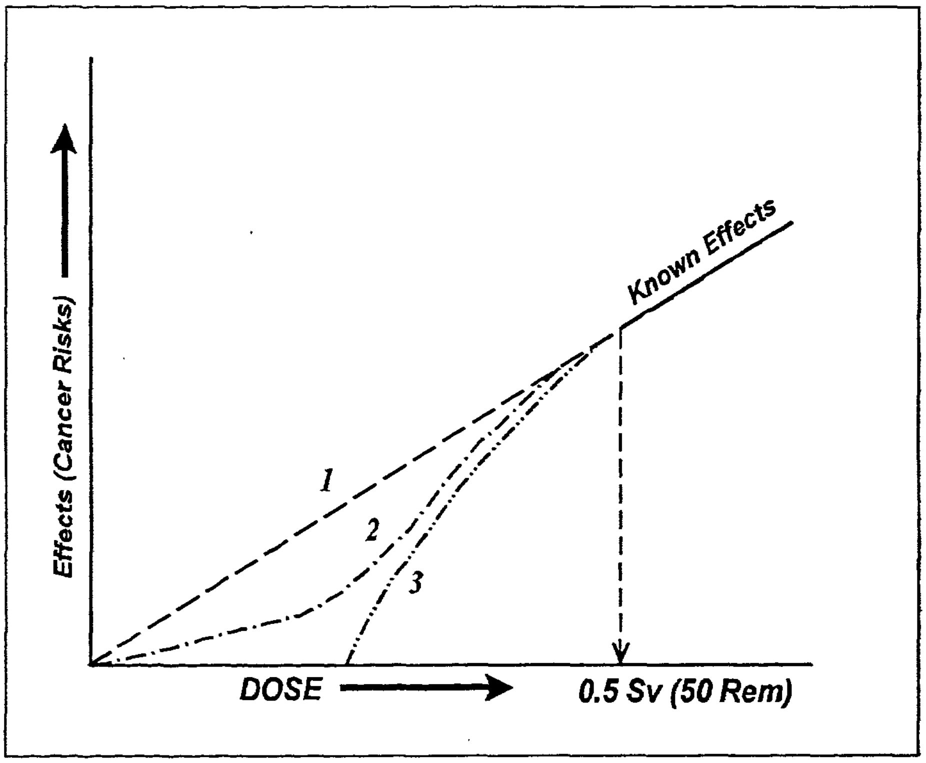


Figure 7.1 Three general models used to predict risk from radiation dose. Models are used because scientists have yet to reliably detect changes in cancer incidence following low doses of radiation. Risks from radiation are primarily based on effects observed from persons receiving high doses (e.g., Hiroshima and Nagasaki atomic bomb survivors). Regulatory dose limits are set well below levels where any health effects have been observed (Figure adapted from NRC 1999).

7.2 Background Radiation

Radiation is a naturally-occurring phenomenon that has been in the environment since the beginning of time. There are several sources of natural radiation: cosmic and cosmogenic radiation (from outer space and the earth's atmosphere), terrestrial radiation (from the earth's crust), and internal radiation (naturally-occurring radiation in our bodies, such as ^{40}K). The most common sources of terrestrial radiation are uranium, thorium, and their decay products. Potassium-40 is another source of terrestrial radiation. While not a major radiation source, ^{40}K may be enhanced in the southeastern New Mexico environment due to local potash mining. Radon gas, a decay product of uranium, is the most widely known naturally-occurring terrestrial radionuclide. In addition to natural radioactivity, small amounts of radioactivity from above-ground nuclear weapons tests that occurred from 1945 through 1980 and the 1986 Chernobyl nuclear accident are also present in the environment. Together, these sources of radiation are called "background" radiation. Every human is constantly exposed to background radiation. Exposure to radioactivity from weapons testing fallout is quite small compared to natural radioactivity and continually gets smaller as radionuclides decay.

Naturally-occurring radiation in our environment can deliver both internal and external doses. Internal dose is received as a result of the

Table 7.1 Annual estimated average radiation dose received by a member of the population of the United States from naturally-occurring radiation sources (adapted from NCRP-1987).

	Average Annual Effective Dose Equivalent	
Source	(mSv)	(mrem)
Inhaled (Radon and Decay Products)	2	200
Internal Radionuclides	0.39	39
Terrestrial Radiation	0.28	28
Cosmic Radiation	0.27	27
Cosmogenic Radioactivity	0.01	1
Rounded Total From Natural Sources	3	300

intake of radionuclides. The major routes of intake of radionuclides for members of the public are ingestion and inhalation. Ingestion includes the intake of the radionuclides from eating and drinking contaminated food and drink. Inhalation includes the intake of radionuclides through breathing dust particles containing radioactive materials. External dose can occur from submersion in contaminated air or deposition of contaminants on surfaces. The average annual dose received by a member of the public from naturally-occurring radionuclides is about 3 mSv (300 mrem) (Table 7.1).

7.3 Dose from Air Emissions

The National Emission Standards for Hazardous Air Pollutants issued by the EPA set limits for radionuclide emissions to air (40 § CFR 61). Compliance procedures for DOE facilities [40 § CFR 61.93(a)] require the use of CAP88 or AIRDOS-PC computer models, or an equivalent, to calculate dose to members of the public. For the determination of the radiation dose received by members of the public, WIPP used the computer model CAP88-PC, version 2.0. Source term input for the program was determined by radiochemical analyses of periodic air samples taken from the effluent Stations A, B, and C (see Section 4.1). Air samples were analyzed for ^{241}Am, $^{239+240}$Pu, and ^{238}Pu because they constitute over 98 percent of the dose potential for contact-handled waste. Measured activity values greater than the MDA were used as a part of the source term for the air emission pathway and, for measured results less than the MDA, the MDA value was used as part of the source term (see Table 4.1). CAP88 dose calculations are based on the assumption that exposed persons remain at home during the entire year and all vegetables, milk, and meat consumed are home produced. Thus, this dose calculation is a maximum potential dose which encompasses dose from inhalation, submersion, deposition, and ingestion of air emitted radionuclides.

7.3.1 Maximally Exposed Individual from Air Emission Pathway

For 1999, the CAP88 model predicted the highest dose to someone residing near WIPP to be at the Smith Ranch approximately 4 km (2.5 mi) northwest of WIPP. Results showed the whole body dose potentially received by someone residing at this location to be about 2.2×10^{-8} mSv (2.2×10^{-6} mrem) per year. The critical organ dose was less than 3.9×10^{-7} mSv (3.9×10^{-5} mrem) per year. This potential whole body dose is 2.2×10^{-5} percent of the whole body dose limits of 0.1 mSv (10 mrem) per year specified in 40 § CFR 61.92. The dose to a hypothetical person residing year-round at the WIPP fence line was estimated to be 3.1 $x10^{-7}$ mSv ($3.1x10^{-5}$ mrem) per year whole body and $5.3x10^{-6}$ mSv ($5.3x10^{-4}$ mrem) per year to the critical organ.

7.4 Total Potential Dose from WIPP Operations

The radiation dose received by members of the public as a result of the management and storage of TRU radioactive wastes at any disposal facility operated by DOE is regulated under 40 § CFR 191 Subpart A. Specific standards state that the combined annual dose to any member of the public in the general environment shall not exceed 0.25 mSv (25 mrem) to the whole body and 0.75 mSv (75 mrem) to any critical organ. Section 7.3 discussed the potential dose received from radionuclides released to the air from WIPP. The following sections discuss the potential dose through other pathways and the total potential dose a member of the public may have received from WIPP operations during 1999.

7.4.1 Potential Dose from Water Ingestion Pathway

The potential dose to individuals from the ingestion of WIPP-related radionuclides transported in water is estimated to be nonexistent for several reasons. Drinking water for communities near WIPP comes from groundwater sources which are not expected to be affected by potential WIPP contaminants (based on current radionuclide transport scenarios summarized in the *WIPP Safety Analysis Report* [DOE/WIPP 95-2065, Rev. 3]). The only credible pathway for contaminants from WIPP to accessible ground water is through the Culebra member of the Rustler Formation and the Dewey Lake Formation (DOE/CAO 96-2184). Water from the Culebra is naturally not potable due to high levels of TDS. Water from the Dewey Lake Formation is suitable for livestock consumption having TDS values below 10,000 mg/L. Groundwater and surface water samples collected around WIPP during 1999 did not contain radionuclide concentrations discernable from those in samples collected prior to WIPP receiving waste.

7.4.2 Potential Dose From Wild Game Ingestion

Game animals sampled during 1999 were mule deer, quail, and catfish. No radionuclides were detected in quail and those detected in deer and catfish were not different from background levels measured prior to commencement of waste shipments to WIPP. Therefore, no dose from WIPP related radionuclides is estimated to have been received by any individual from this pathway during 1999.

7.4.3 Total Potential Dose From All Pathways

The only pathway for which a dose could be estimated was that of air emissions. Air emissions from WIPP were not considered above background ambient air levels. Estimated concentrations of radionuclides in air emissions accounted for the calculable dose from WIPP operations during 1999. The dose potentially received by someone residing 4 km (2.5 mi) northwest of WIPP was calculated to be 2.2 $x10^{-8}$ mSv (2.2 $x10^{-6}$ mrem) per year, whole body, and 3.9 $x10^{-7}$ mSv (3.9 $x10^{-5}$ mrem) per year to the critical organ. This is 8.8 $x10^{-6}$ percent of the whole body dose limits of 0.25 mSv (25 mrem) per year whole body dose and 5.2 $x10^{-5}$ percent of the dose limit of 0.75 mSv (75 mrem) per year specified in 40 § CFR 191.03(b). The dose to a hypothetical person residing year-round at the WIPP fence line was estimated to be 3.1 $x10^{-7}$ mSv (3.1 $x10^{-5}$ mrem) per year whole body and 5.3 $x10^{-6}$ mSv (5.3 $x10^{-4}$ mrem) per year to the critical organ. This is 1.2 $x10^{-4}$ percent of the whole body dose limits of 0.25 mSv (25 mrem) per year whole body dose and 7.1 $x10^{-4}$ percent of the dose limit of 0.75 mSv (75 mrem) per year specified in 40 § CFR 191.03(b).

7.5 Dose to non-human Biota

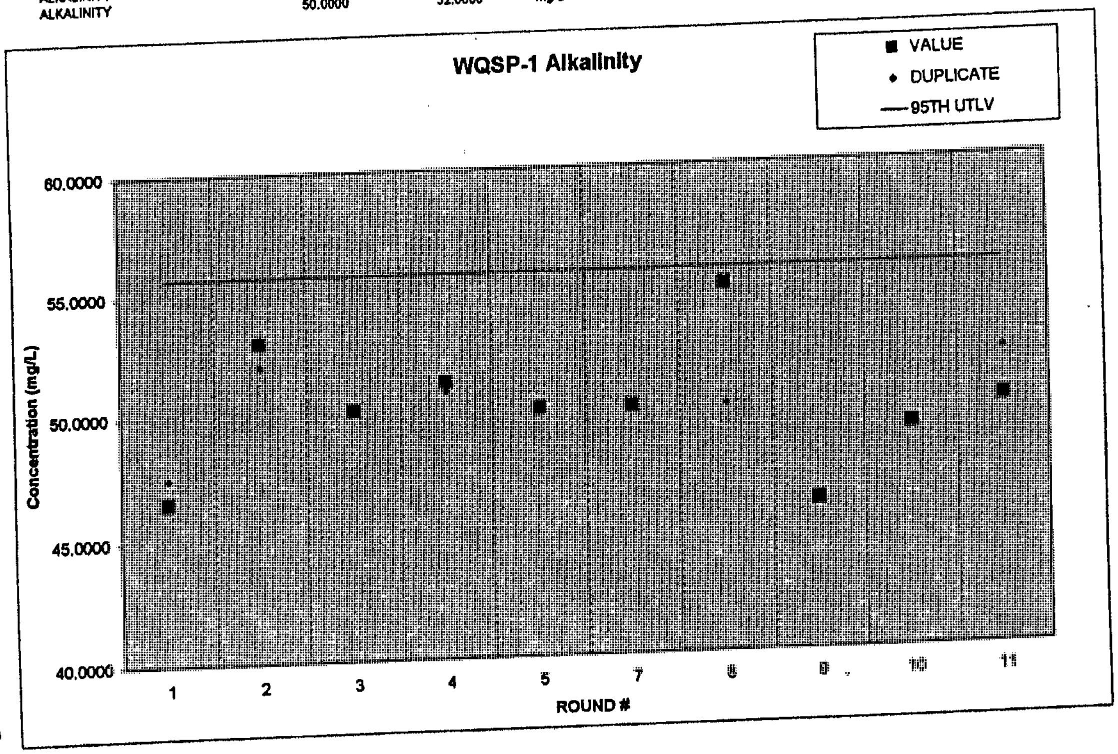
DOE Order 5400.5 lists the environmental radiation protection requirements that WIPP must meet to protect aquatic animals. In addition, dose limits below which no deleterious effects on populations of aquatic and terrestrial organisms have been observed have been discussed by the

WQSP-1 Alkalinity

CAS #	PARAMETER	VALUE	VALUE DUPLICATE	UNITS	MINIMUM DETECTION LIMIT	95TH UTLV	ACID BLANK (AVERAGE)	WATER BLANK (AVERAGE)	ROUND #	DATE ANALYZED	DATE SAMPLED
	ALKALINITY	46.5000	47.5000	mg/L	5.0000	55.7000		< 5.0000	1	08/29/95	08/17/95
	ALKALINITY	53.0000	52.0000	mg/L	5.0000	55.7000		< 5.0000	2	04/25/96	04/11/96
	ALKALINITY	50.1000	50.1000	mg/L	5.0000	55.7000		< 5.0000	3	08/06/96	07/25/96
	ALKALINITY	51.2000	50.8000	mg/L	5.0000	55.7000		< 5.0000	4	04/30/97	04/24/97
	ALKALINITY	50.0000	50.0000	mg/L	5.0000	55.7000		< 5.0000	5	08/26/97	07/24/97
	ALKALINITY	50.0000	50.0000	mg/L	1.0000	55.7000		< 1.0000	7	07/29/98	07/15/98
	ALKALINITY	55.0000	50.0000	mg/L	4.0000	55.7000		< 4.0000	8	03/05/99	03/03/99
	ALKALINITY	46.0000	46.0000	mg/L	4.0000	55.7000		< 4.0000	9	09/08/99	09/01/99
	ALKALINITY	49.0000	49.0000	mg/L	4.0000	55.7000		< 4.0000	10	03/15/00	03/02/00
	ALKALINITY	50.0000	52.0000	mg/L	6.0000	55.7000		< 6.0000	11	09/07/00	09/07/00

Baseline WQSP-1 Alkalinity

Mean	50.12
Standard Error	0.609699379
Median	50.1
Mode	50.1
Standard Deviation	1.928038727
Sample Variance	3.717333333
Kurtosis	0.425984006
Skewness	-0.645680898
Range	6.5
Minimum	46.5
Maximum	53
Sum	501.2
Count	10
Confidence Level(95.0%)	1.37923887



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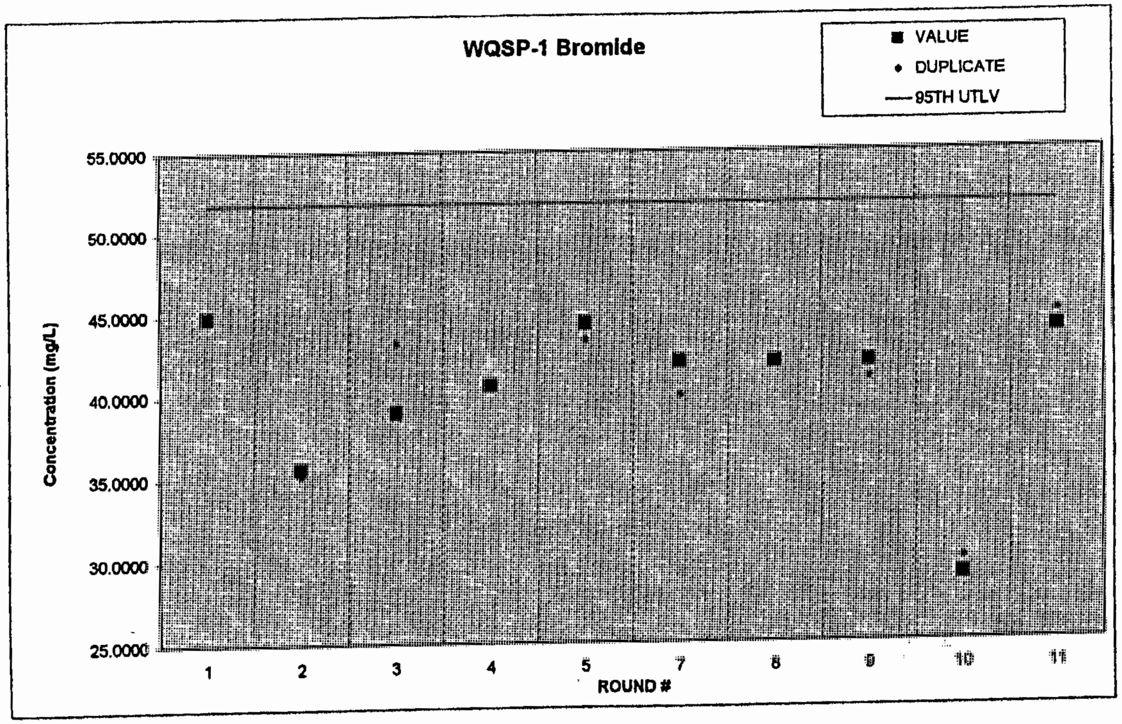
WQSP-1 Bromide

CAS #	PARAMETER	VALUE	VALUE DUPLICATE	UNITS	MINIMUM DETECTION LIMIT	95TH UTLV	ACID BLANK (AVERAGE)	WATER BLANK (AVERAGE)	ROUND #	DATE ANALYZED	DATE SAMPLED
7726-95-6	BROMIDE	44.9000	45.1000	mg/L	2.0000	51.8000		< 2.0000	1	09/01/95	08/17/95
7726-95-6	BROMIDE	35.6000	35.2000	mg/L	2.0000	51.8000		< 2.0000	2	04/25/96	04/11/96
7726-95-6	BROMIDE	39.0000	43.3000	mg/L	2.0000	51.8000		4.3000	3	08/20/96	07/25/96
7726-95-6	BROMIDE	40.6000	40.8000	mg/L	2.0000	51.8000		< 2.0000	4	05/02/97	04/24/97
7726-95-6	BROMIDE	44.4000	43.4000	mg/L	4.0000	51.8000		< 4.0000	5	09/17/97	07/24/97
7726-95-6	BROMIDE	42.0000	40.0000	mg/L	0.1000	51.8000		< 0.5000	7	07/23/98	07/15/98
7726-95-6	BROMIDE	42.0000	42.0000	mg/L	0.2000	51.8000		< 0.2000	8	03/05/99	03/03/99
7726-95-6	BROMIDE	42.0000	41.0000	mg/L	0.2000	51.6000		< 0.2000	9	09/07/99	09/01/99
7726-95-6	BROMIDE	29.0000	30.0000	mg/L	0.2000	51.8000		< 0.2000	10	03/06/00	03/02/00
7726-95-6	BROMIDE	44.0000	45.0000	mg/L	0.2000	51.8000		< 0.2000	11	09/07/00	09/07/00

Baseline WQSP-1 Bromide	
Mean	41.23
Standard Error	1.159985632
Median	42.05
Mode	#N/A
Standard Deviation	3.66819665
Sample Variance	13.45566667
Kurtosis	-0.844710264
Skewness	-0.705711898
Range	9.9
Minimum	35.2
Maximum	45.1
Sum	412.3
Count	10
Confidence Level(95.0%)	2.624071806

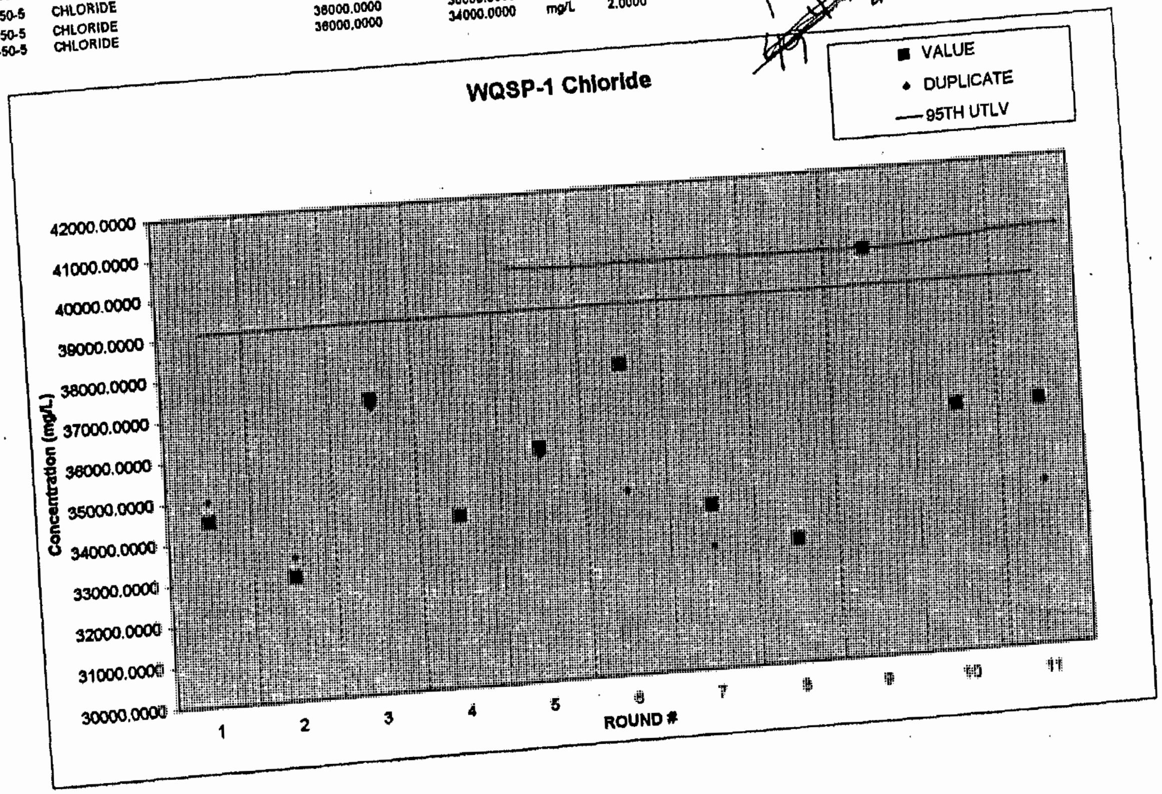


WQSP-1 Chloride

CAS #	PARAMETER	VALUE	VALUE DUPLICATE	UNITS	MINIMUM DETECTION LIMIT	95TH UTLV	ACID BLANK (AVERAGE)	WATER BLANK (AVERAGE)	ROUND #	DATE ANALYZED	DATE SAMPLED
7782-50-5	CHLORIDE	34500.0000	35000.0000	mg/L	5.0000	39105.0000		< 5.0000	1	08/23/95	08/17/95
7782-50-5	CHLORIDE	33000.0000	33500.0000	mg/L	5000.0000	39105.0000		< 5.0000	2	04/22/96	04/11/96
7782-50-5	CHLORIDE	37200.0000	37000.0000	mg/L	5.0000	39105.0000		< 5.0000	3	08/06/96	07/25/96
7782-50-5	CHLORIDE	34200.0000	34200.0000	mg/L	250.0000	39105.0000		< 5.0000	4	05/01/97	04/24/97
7782-50-5	CHLORIDE	35700.0000	35500.0000	mg/L	2500.0000	39105.0000		< 5.0000	5	08/29/97	07/24/97
7782-50-5	CHLORIDE	37600.0000	34500.0000	mg/L	2500.0000	39105.0000			6	03/19/98	03/05/98
7782-50-5	CHLORIDE	34000.0000	33000.0000	mg/L	0.5000	39105.0000		1.0100	7	07/28/98	07/15/98
7782-50-5	CHLORIDE	33000.0000	33000.0000	mg/L	0.5000	39105.0000		< 0.5000	8	03/03/99	03/03/99
7782-50-5	CHLORIDE	40000.0000	40000.0000	mg/L	0.5000	39105.0000		< 0.5000	9	09/07/99	09/01/99
7782-50-5	CHLORIDE	36000.0000	36000.0000	mg/L	0.5000	39105.0000		< 0.5000	10	03/06/00	03/02/00
7782-50-5	CHLORIDE	36000.0000	34000.0000	mg/L	2.0000	39105.0000		< 2.0000	11	09/21/00	09/07/00

40,472

Baseline WQSP-1 Chloride	
Mean	34980
Standard Error	439.1405748
Median	34750
Mode	34200
Standard Deviation	1388.684429
Sample Variance	1928444.444
Kurtosis	-0.68847329
Skewness	0.395892343
Range	4200
Minimum	33000
Maximum	37200
Sum	349800
Count	10
Confidence Level(95.0%)	993.4057539

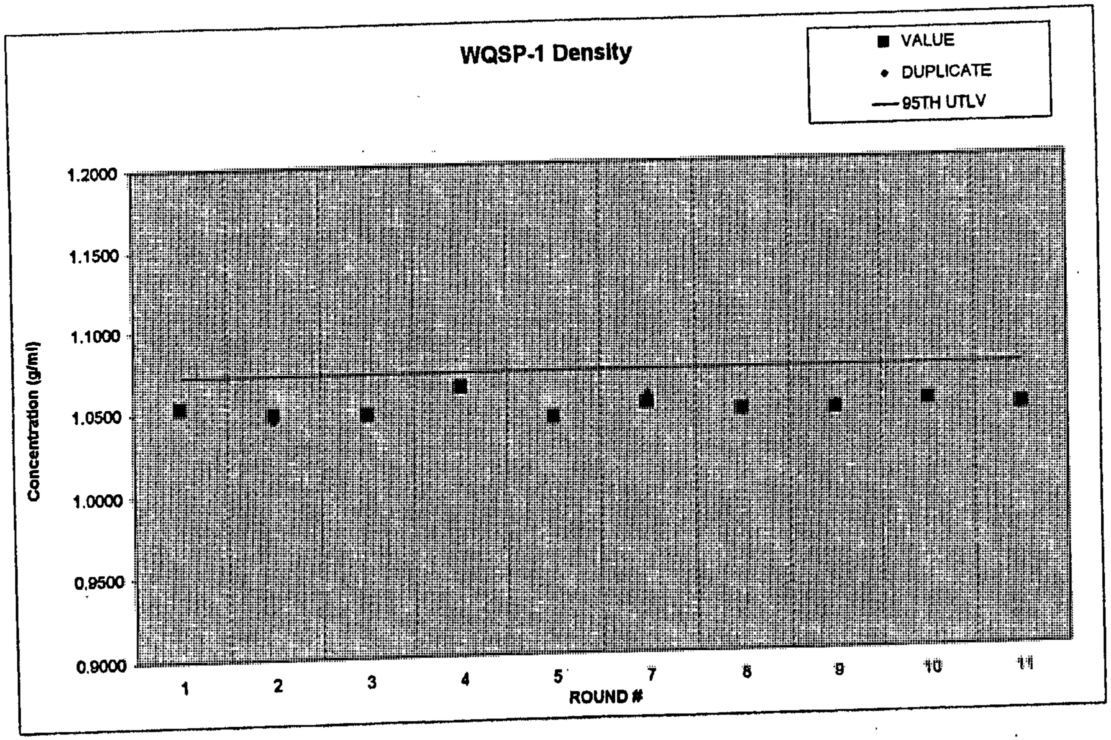


WQSP-1 Density

CAS #	PARAMETER	VALUE	VALUE DUPLICATE	UNITS	MINIMUM DETECTION LIMIT	95TH UTLV	ACID BLANK (AVERAGE)	WATER BLANK (AVERAGE)	ROUND #	DATE ANALYZED	DATE SAMPLED
	DENSITY	1.0530	1.0530	g/mL	0.0000	1.0720			1	08/22/95	08/17/95
	DENSITY	1.0480	1.0440	g/mL	0.0000	1.0720			2	04/18/96	04/11/96
	DENSITY	1.0470	1.0480	g/mL	0.0000	1.0720			3	08/08/96	07/25/96
	DENSITY	1.0630	1.0640	g/mL	N/A	1.0720			4	05/02/97	04/24/97
	DENSITY	1.0430	1.0450	g/mL	N/A	1.0720			5	09/02/97	07/24/97
	DENSITY	1.0510	1.0570	g/mL	—	1.0720			7	07/22/98	07/15/98
	DENSITY	1.0460	1.0440	g/mL	N/A	1.0720			8	03/05/99	03/03/99
	DENSITY	1.0454	1.0487	g/mL	N/A	1.0720		1.0037	9	09/03/99	09/01/99
	DENSITY	1.0500	1.0500	g/mL	N/A	1.0720		1.0000 N/A	10	03/21/00	03/02/00
	DENSITY	1.0459	1.0449	g/mL	N/A	1.0720			11	09/15/00	09/07/00

Baseline WQSP-1 Density

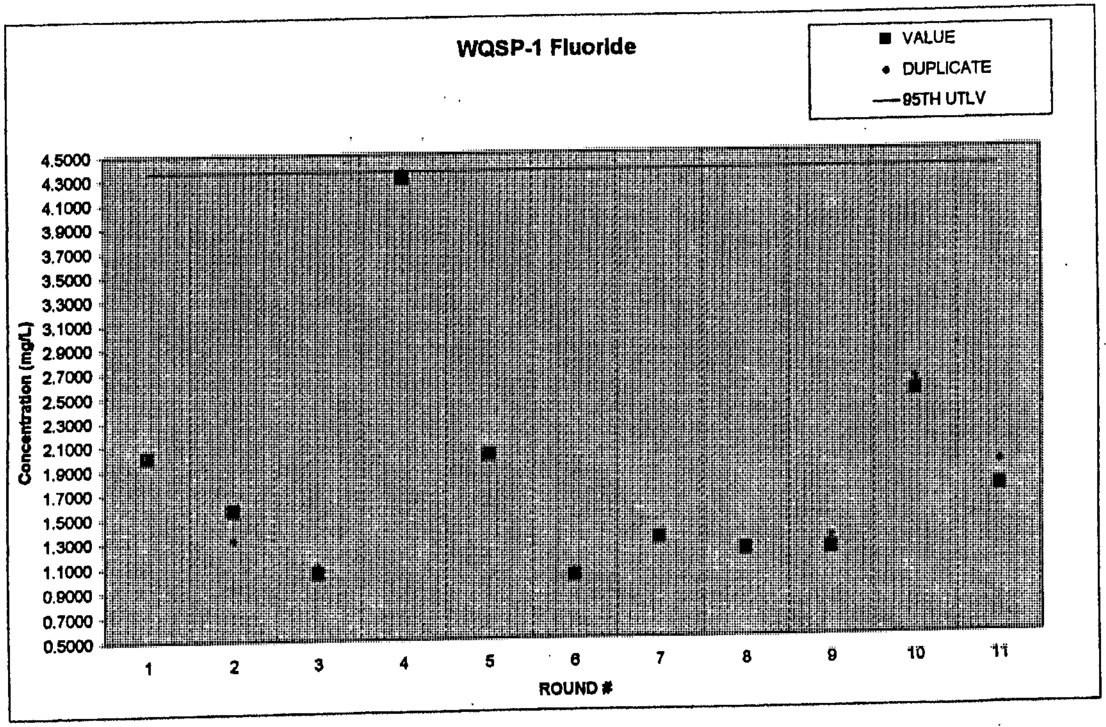
Mean	1.0508
Standard Error	0.002365493
Median	1.048
Mode	1.053
Standard Deviation	0.007480345
Sample Variance	5.59556E-05
Kurtosis	-0.166456004
Skewness	1.013458212
Range	0.021
Minimum	1.043
Maximum	1.064
Sum	10.508
Count	10
Confidence Level(95.0%)	0.00535112



WQSP-1 Fluoride

CAS #	PARAMETER		VALUE		VALUE DUPLICATE	UNITS	MINIMUM DETECTION LIMIT	95TH UTLV	ACID BLANK (AVERAGE)		WATER BLANK (AVERAGE)	ROUND #	DATE ANALYZED	DATE SAMPLED
	FLUORIDE	<	2.0000	<	2.0000	mg/L	2.0000	4.3600		<	2.0000	1	08/30/95	08/17/95
	FLUORIDE		1.5600		1.3200	mg/L	1.0000	4.3600		<	1.0000	2	05/10/96	04/11/96
	FLUORIDE		1.0400		1.0900	mg/L	1.0000	4.3600		<	1.0000	3	08/27/96	07/25/96
	FLUORIDE		4.3000		4.3600	mg/L	2.0000	4.3600		<	1.0000	4	05/02/97	04/24/97
	FLUORIDE	<	2.0000	<	2.0000	mg/L	2.0000	4.3600		<	2.0000	5	09/17/97	07/24/97
	FLUORIDE	<	1.0000	<	1.0000	mg/L	1.0000	4.3600		<	2.0000	6	03/23/98	03/05/98
	FLUORIDE		1.3000		1.3000	mg/L	0.1000	4.3600		<	0.1000	7	07/27/98	07/15/98
	FLUORIDE		1.2000		1.2000	mg/L	0.1000	4.3600		<	0.1000	8	03/17/99	03/03/99
	FLUORIDE		1.2000		1.3000	mg/L	0.1000	4.3600		<	0.1000	9	09/08/99	09/01/99
	FLUORIDE		2.5000		2.6000	mg/L	0.1000	4.3600		<	0.1000	10	03/20/00	03/02/00
	FLUORIDE		1.7000		1.9000	mg/L	0.1000	4.3600		<	0.1000	11	08/15/00	09/07/00

Baseline WQSP-1 Fluoride	
Mean	2.167
Standard Error	0.379859769
Median	2
Mode	2
Standard Deviation	1.201222063
Sample Variance	1.442934444
Kurtosis	0.633737627
Skewness	1.339826619
Range	3.32
Minimum	1.04
Maximum	4.36
Sum	21.67
Count	10
Confidence Level(95.0%)	0.859303153

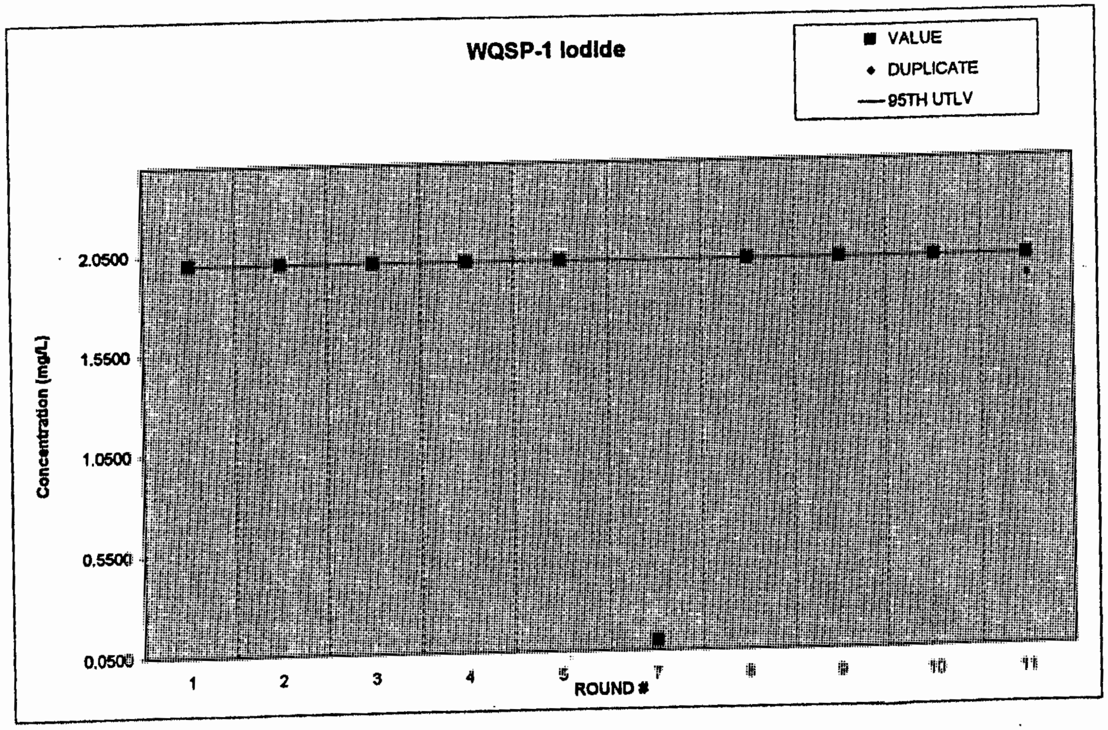


Iodide

WQSP-1 Iodide

CAS #	PARAMETER	VALUE	VALUE DUPLICATE	UNITS	MINIMUM DETECTION LIMIT	95TH UTLV	ACID BLANK (AVERAGE)	WATER BLANK (AVERAGE)	ROUND #	DATE ANALYZED	DATE SAMPLED
	IODIDE	< 2.0000	< 2.0000	mg/L	2.0000	2.0000		< 2.0000	1	08/18/95	08/17/95
	IODIDE	< 2.0000	< 2.0000	mg/L	2.0000	2.0000		< 2.0000	2	04/12/96	04/11/96
	IODIDE	< 2.0000	< 2.0000	mg/L	2.0000	2.0000		< 2.0000	3	07/26/96	07/25/96
	IODIDE	< 2.0000	< 2.0000	mg/L	2.0000	2.0000		< 2.0000	4	04/28/97	04/24/97
	IODIDE	< 2.0000	< 2.0000	mg/L	2.0000	2.0000		< 2.0000	5	07/25/97	07/24/97
	IODIDE	0.0980	0.0860	mg/L	0.0500	2.0000		< 0.0500	7	08/10/98	07/15/98
	IODIDE	< 2.0000	< 2.0000	mg/L	2.0000	2.0000		< 2.0000	8	03/16/99	03/03/99
	IODIDE	< 2.0000	< 2.0000	mg/L	2.0000	2.0000		< 2.0000	9	09/13/99	09/01/99
	IODIDE	< 2.0000	< 2.0000	mg/L	2.0000	2.0000		< 2.0000	10	03/03/00	03/02/00
	IODIDE	< 2.0000	1.9000	mg/L	2.0000	2.0000		< 2.0000	11	09/21/00	09/07/00

Baseline WQSP-1 Iodide		
Mean		2
Standard Error		0
Median		2
Mode		2
Standard Deviation		0
Sample Variance		0
Kurtosis	#DIV/0!	
Skewness	#DIV/0!	
Range		0
Minimum		2
Maximum		2
Sum		20
Count		10
Confidence Level(95.0%)		0



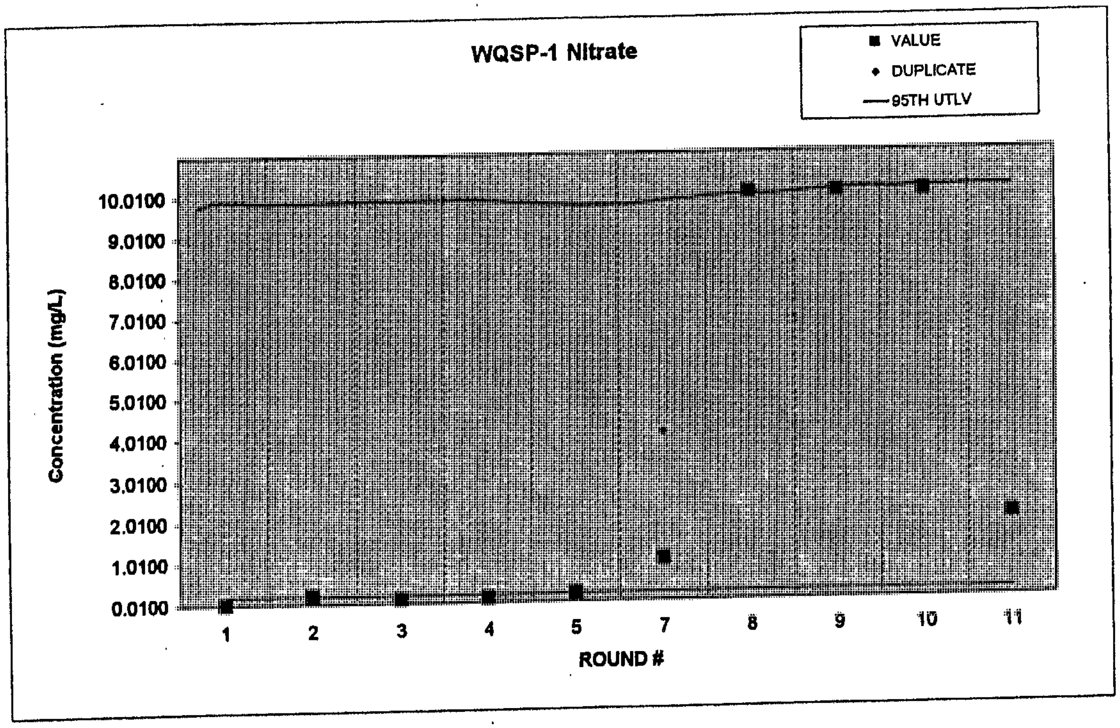
WQSP-1 Nitrate

CAS #	PARAMETER		VALUE		VALUE DUPLICATE	UNITS	MINIMUM DETECTION LIMIT	95TH UTLV	ACID BLANK (AVERAGE)		WATER BLANK (AVERAGE)	ROUND #	DATE ANALYZED	DATE SAMPLED
7727-37-9	NITROGEN, NO3 (AS N)	<	0.0100	<	0.0100	mg/L	0.1000	0.2000		<	0.1000	1	08/30/95	08/17/95
7727-37-9	NITROGEN, NO3 (AS N)	<	0.2000	<	0.2000	mg/L	0.2000	0.2000		<	0.1000	2	04/25/96	04/11/96
7727-37-9	NITROGEN, NO3 (AS N)	<	0.1000	<	0.1000	mg/L	0.1000	0.2000		<	0.1000	3	08/06/96	07/25/96
7727-37-9	NITROGEN, NO3 (AS N)	<	0.1000	<	0.1000	mg/L	0.1000	0.2000		<	0.1000	4	05/02/97	04/24/97
7727-37-9	NITROGEN, NO3 (AS N)	<	0.2000	<	0.2000	mg/L	0.2000	0.2000		<	0.1000	5	09/23/97	07/24/97
7727-37-9	NITROGEN, NO3 (AS N)	<	1.0000		4.1000	mg/L	0.2000	0.2000		<	0.2000	7	07/16/98	07/15/98
7727-37-9	NITROGEN, NO3 (AS N)	<	10.0000	<	10.0000	mg/L	0.2000	0.2000		<	0.2000	8	03/03/99	03/03/99
7727-37-9	NITROGEN, NO3 (AS N)	<	10.0000	<	10.0000	mg/L	0.2000	0.2000		<	0.2000	9	09/07/99	09/01/99
7727-37-9	NITROGEN, NO3 (AS N)	<	10.0000	<	10.0000	mg/L	0.2000	0.2000		<	0.2000	10	03/06/00	03/02/00
7727-37-9	NITROGEN, NO3 (AS N)	<	2.0000	<	2.0000	mg/L	2.0000	0.2000		<	0.2000	11	09/17/00	09/07/00

<10.0

Baseline WQSP-1 Nitrate

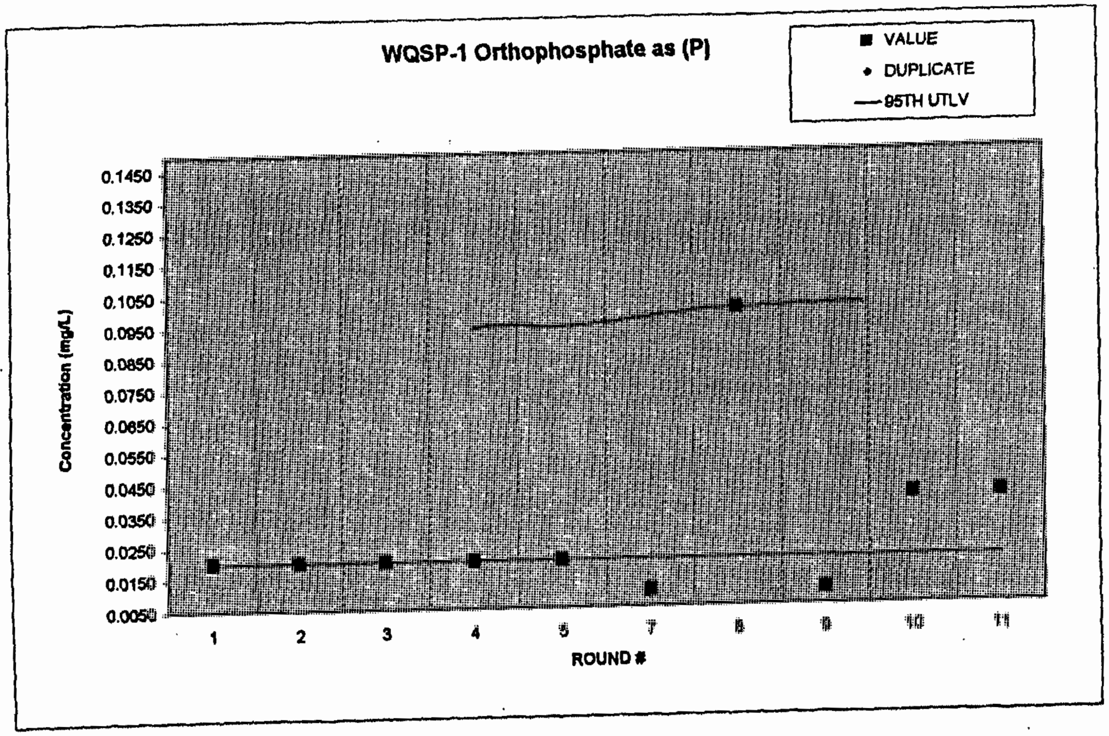
Mean	0.122
Standard Error	0.02388863
Median	0.1
Mode	0.2
Standard Deviation	0.075542483
Sample Variance	0.005706667
Kurtosis	-1.231612945
Skewness	-0.307433623
Range	0.19
Minimum	0.01
Maximum	0.2
Sum	1.22
Count	10
Confidence Level(95.0%)	0.054039878



WQSP-1 Orthophosphate

CAS #	PARAMETER	VALUE	VALUE DUPLICATE	UNITS	MINIMUM DETECTION LIMIT	95TH UTLV	ACID BLANK (AVERAGE)	WATER BLANK (AVERAGE)	ROUND #	DATE ANALYZED	DATE SAMPLED
	ORTHOPHOSPHATE (AS P)	< 0.0200	< 0.0200	mg/L	0.0200	0.0200		< 0.0200	1	08/18/18	08/17/95
	ORTHOPHOSPHATE (AS P)	< 0.0200	< 0.0200	mg/L	0.0200	0.0200		< 0.0200	2	04/12/96	04/11/96
	ORTHOPHOSPHATE (AS P)	< 0.0200	< 0.0200	mg/L	0.0200	0.0200		< 0.0200	3	07/26/96	07/25/96
	ORTHOPHOSPHATE (AS P)	< 0.0200	< 0.0200	mg/L	0.0200	0.0200		< 0.0200	4	04/28/97	04/24/97
	ORTHOPHOSPHATE (AS P)	< 0.0200	< 0.0200	mg/L	0.0200	0.0200		< 0.0200	5	07/25/97	07/24/97
	ORTHOPHOSPHATE (AS P)	< 0.0100	< 0.0100	mg/L	0.0100	0.0200		< 0.0100	7	07/15/98	07/15/98
	ORTHOPHOSPHATE (AS P)	< 0.1000	< 0.1000	mg/L	0.0100	0.0200		< 0.0100	8	03/04/99	03/03/99
	ORTHOPHOSPHATE (AS P)	< 0.0100	0.0110	mg/L	0.0100	0.0200 L.1		< 0.0100	9	09/03/99	09/01/99
	ORTHOPHOSPHATE (AS P)	< 0.0400	< 0.0400	mg/L	0.0400	0.0200		< 0.0400	10	03/03/00	03/02/00
	ORTHOPHOSPHATE (AS P)	< 0.0400	< 0.0400	mg/L	0.0400	0.0200		< 0.0400	11	09/08/00	09/07/00

Baseline WQSP-1 Orthophosphate	
Mean	0.02
Standard Error	1.38833E-10
Median	0.02
Mode	0.02
Standard Deviation	4.3903E-10
Sample Variance	1.92747E-19
Kurtosis	-2.571428571
Skewness	1.185854123
Range	0
Minimum	0.02
Maximum	0.2
Sum	10
Count	10
Confidence Level(95.0%)	3.14063E-10

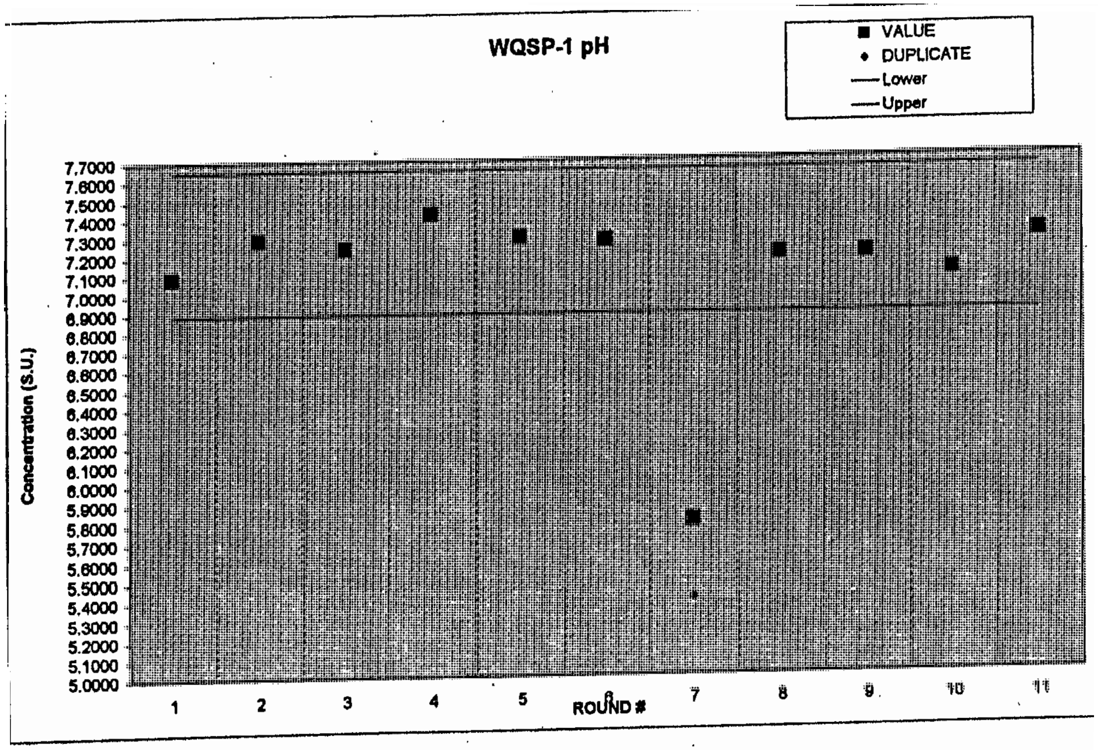


WQSP-1 pH

CAS #	PARAMETER	VALUE	VALUE DUPLICATE	UNITS	MINIMUM DETECTION LIMIT	95TH UTLV Lower	Upper	ACID BLANK (AVERAGE)	WATER BLANK (AVERAGE)	ROUND #	DATE ANALYZED	DATE SAMPLED
pH		7.0900	7.1100	SU	0.0000	6.89	7.65			1	08/18/95	08/17/95
pH		7.2900	7.2800	SU	0.0000	6.89	7.65			2	04/12/96	04/11/96
pH		7.2400	7.2300	SU	0.0000	6.89	7.65			3	07/26/96	07/25/96
pH		7.4200	7.4400	SU	N/A	6.89	7.65			4	04/28/97	04/24/97
pH		7.2050	7.3150	SU	N/A	6.89	7.65			5	07/25/97	07/24/97
pH		7.2800	7.3000	SU	N/A	6.89	7.65			6	03/06/98	03/05/98
pH		5.8000	5.4000	SU	—	6.89	7.65			7	07/15/98	07/15/98
pH		7.2000	7.2000	SU	N/A	6.89	7.65			8	03/03/99	03/03/99
pH		7.2000	7.2000	SU	N/A	6.89	7.65			9	09/01/99	09/01/99
pH		7.1000	7.1000	SU	N/A	6.89	7.65			10	03/07/00	03/02/00
pH		7.3000	7.3000	SU	N/A	6.8900	7.6500			11	09/07/00	09/07/00
pH												

Baseline WQSP-1 pH

Mean	7.271
Standard Error	0.035752234
Median	7.285
Mode	#N/A
Standard Deviation	0.11305849
Sample Variance	0.012782222
Kurtosis	-0.249308166
Skewness	-0.188407515
Range	0.35
Minimum	7.09
Maximum	7.44
Sum	72.71
Count	10
Confidence Level(95.0%)	0.080877233



Range 5.6-8.8 – Seems wrong
Stay with old Range

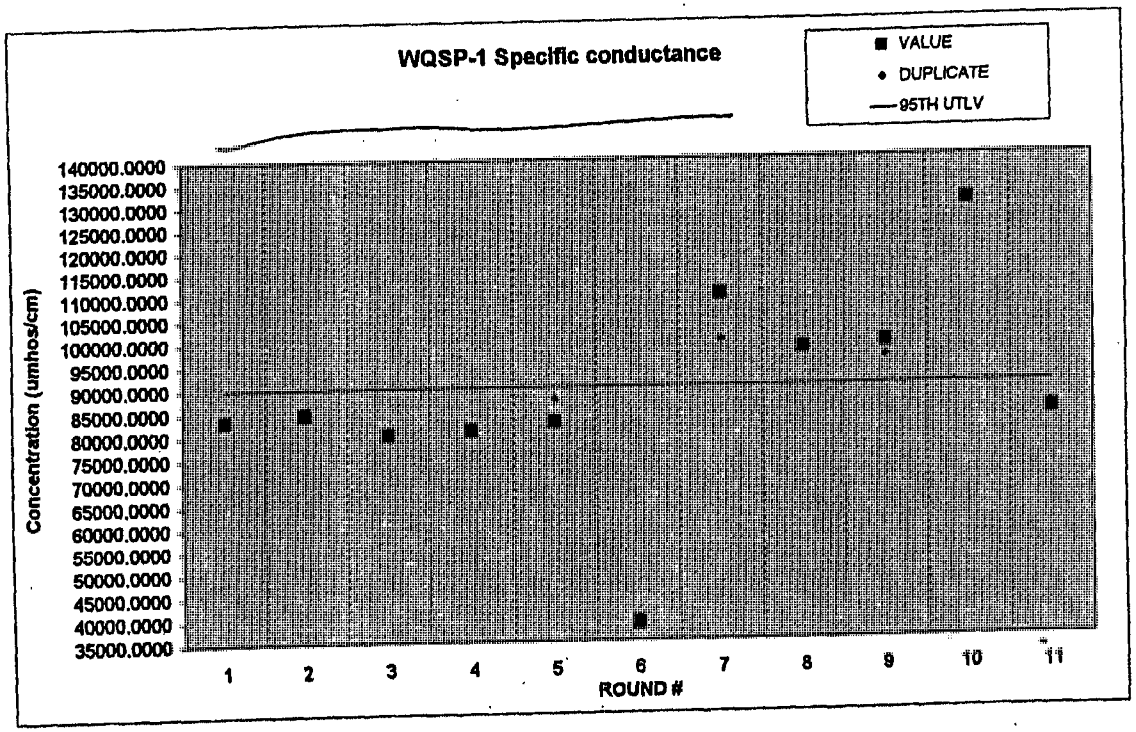
WQSP-1 Specific conductance

CAS #	PARAMETER	VALUE	VALUE DUPLICATE	UNITS	MINIMUM DETECTION LIMIT	95TH UTLV	ACID BLANK (AVERAGE)	WATER BLANK (AVERAGE)	ROUND #	DATE ANALYZED	DATE SAMPLED
	SPECIFIC CONDUCTANCE	83400.0000	83800.0000	umhos/cm	1.0000	90030.0000			1	08/18/95	08/17/95
	SPECIFIC CONDUCTANCE	84700.0000	85100.0000	umhos/cm	1.0000	90030.0000			2	04/18/96	04/11/96
	SPECIFIC CONDUCTANCE	80100.0000	80100.0000	umhos/cm	3.0000	90030.0000			3	08/20/96	07/25/96
	SPECIFIC CONDUCTANCE	80950.0000	80900.0000	umhos/cm	3.0000	90030.0000			4	05/02/97	04/24/97
	SPECIFIC CONDUCTANCE	82500.0000	87300.0000	umhos/cm	3.0000	90030.0000			5	08/29/97	07/24/97
	SPECIFIC CONDUCTANCE	38700.0000	39900.0000	umhos/cm	3.0000	90030.0000			6	03/23/98	03/05/98
	SPECIFIC CONDUCTANCE	110000.0000	100000.0000	umhos/cm	—	90030.0000		4.6000	7	07/27/98	07/15/98
	SPECIFIC CONDUCTANCE	98000.0000	98000.0000	umhos/cm		90030.0000			8	03/05/99	03/03/99
	SPECIFIC CONDUCTANCE	99000.0000	96000.0000	umhos/cm		90030.0000		4.6000	9	09/03/99	09/01/99
	SPECIFIC CONDUCTANCE	130000.0000	130000.0000	umhos/cm		90030.0000		4.6000	10	03/07/00	03/02/00
	SPECIFIC CONDUCTANCE	84000.0000	85000.0000	umhos/cm		90030.0000		N/A	11	09/07/00	9/7/00

175,000

Baseline WQSP-1 Specific conductance

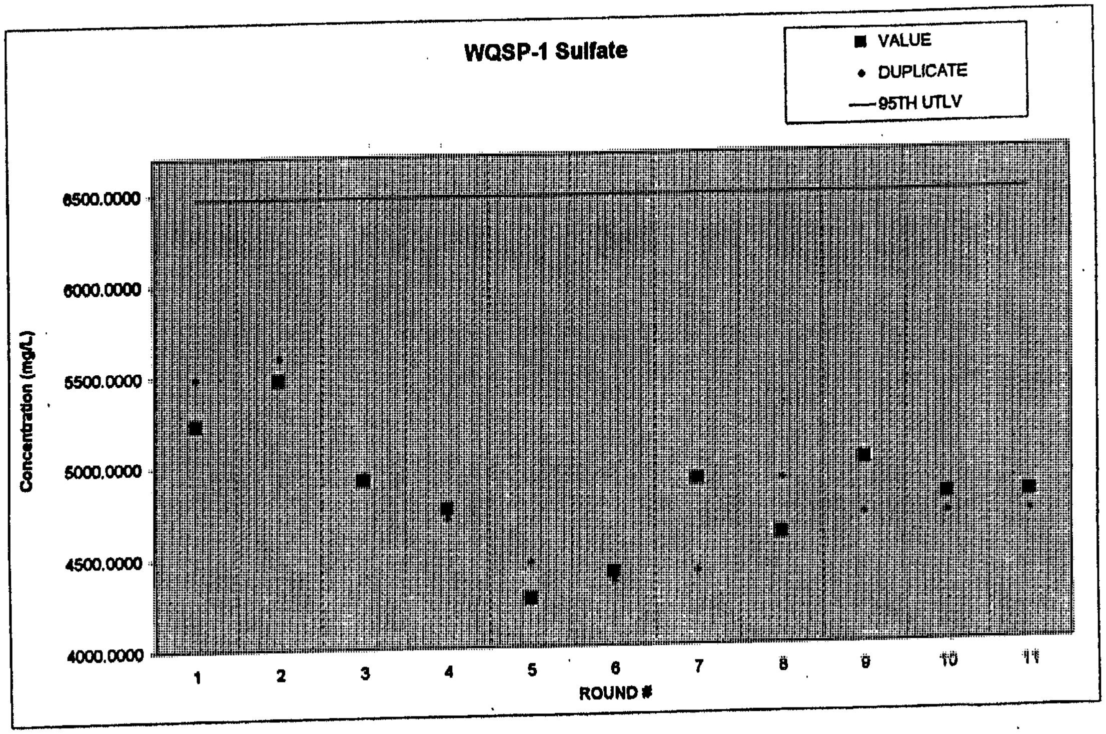
Mean	82885
Standard Error	761.1413214
Median	82950
Mode	80100
Standard Deviation	2406.940197
Sample Variance	5793361.111
Kurtosis	-0.661780487
Skewness	0.453008235
Range	7200
Minimum	80100
Maximum	87300
Sum	828850
Count	10
Confidence Level(95.0%)	1721.822604



WQSP-1 Sulfate

CAS #	PARAMETER	VALUE	VALUE DUPLICATE	UNITS	MINIMUM DETECTION LIMIT	95TH UTLV	ACID BLANK (AVERAGE)		WATER BLANK (AVERAGE)	ROUND #	DATE ANALYZED	DATE SAMPLED
	SULFATE	5230.0000	5490.0000	mg/L	10.0000	6477.0000		<	10.0000	1	08/29/95	08/17/95
	SULFATE	5480.0000	5600.0000	mg/L	2500.0000	6477.0000		<	10.0000	2	04/25/96	04/11/96
	SULFATE	4920.0000	4950.0000	mg/L	1000.0000	6477.0000		<	10.0000	3	08/21/96	07/25/96
	SULFATE	4760.0000	4700.0000	mg/L	10.0000	6477.0000		<	10.0000	4	05/01/97	04/24/97
	SULFATE	4260.0000	4460.0000	mg/L	2500.0000	6477.0000		<	10.0000	5	09/03/97	07/24/97
	SULFATE	4400.0000	4350.0000	mg/L	1000.0000	6477.0000		<	10.0000	6	03/11/98	03/05/98
	SULFATE	4900.0000	4400.0000	mg/L	0.5000	6477.0000		<	0.5000	7	07/28/98	07/15/98
	SULFATE	4600.0000	4900.0000	mg/L	0.5000	6477.0000		<	0.5000	8	03/03/99	03/03/99
	SULFATE	5000.0000	4700.0000	mg/L	0.5000	6477.0000		<	0.5000	9	09/07/99	09/01/99
	SULFATE	4800.0000	4700.0000	mg/L	0.5000	6477.0000		<	0.5000	10	03/08/00	03/02/00
	SULFATE	4800.0000	4700.0000	mg/L	0.5000	6477.0000		<	0.5000	11	09/07/00	09/07/00
	SULFATE											

Baseline WQSP-1 Sulfate	
Mean	4985
Standard Error	144.4087563
Median	4935
Mode	#N/A
Standard Deviation	456.6605839
Sample Variance	208538.8889
Kurtosis	-1.161655588
Skewness	-0.092244522
Range	1340
Minimum	4260
Maximum	5600
Sum	49850
Count	10
Confidence Level(95.0%)	326.6755514

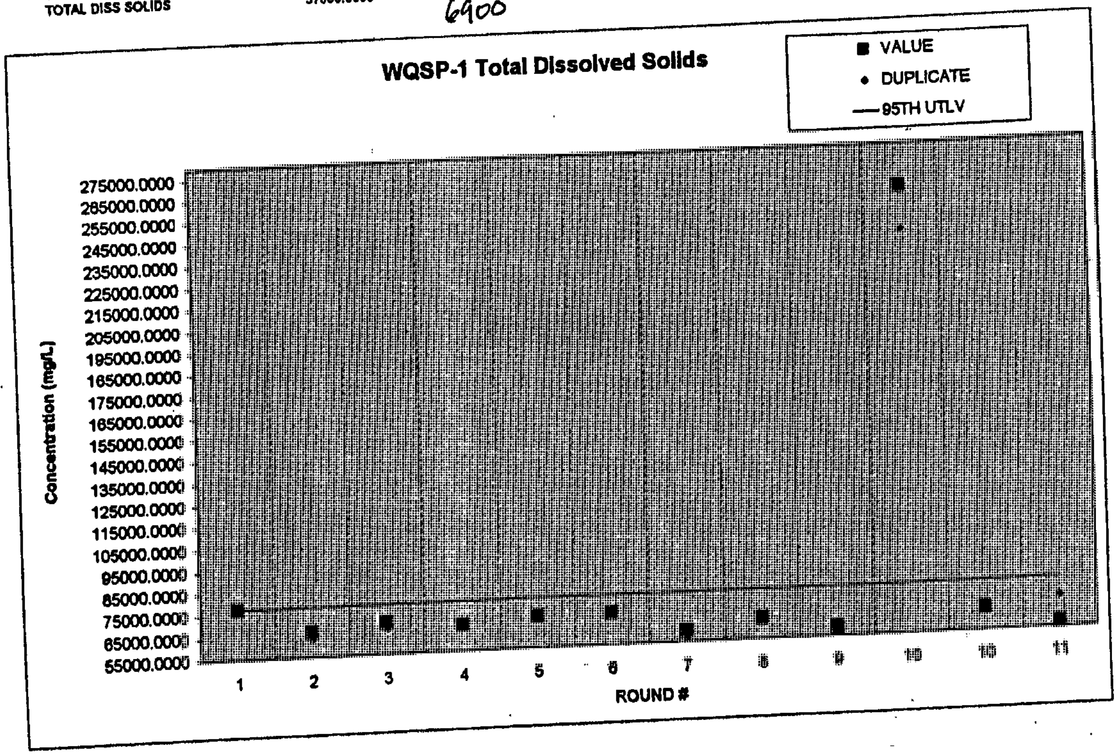


WQSP-1 Total Dissolved Solids

CAS #	PARAMETER	VALUE	VALUE DUPLICATE	UNITS	MINIMUM DETECTION LIMIT	95TH UTLV	ACID BLANK (AVERAGE)		WATER BLANK (AVERAGE)	ROUND #	DATE ANALYZED	DATE SAMPLED
	TOTAL DISS SOLIDS	77400.0000	77600.0000	mg/L	10.0000	77600.0000		<	10.0000	1	08/24/95	08/17/95
	TOTAL DISS SOLIDS	66300.0000	63500.0000	mg/L	2000.0000	77600.0000		<	20.0000	2	04/19/96	04/11/96
	TOTAL DISS SOLIDS	69000.0000	66600.0000	mg/L	200.0000	77600.0000		<	10.0000	3	08/01/96	07/25/96
	TOTAL DISS SOLIDS	66700.0000	66300.0000	mg/L	10.0000	77600.0000		<	10.0000	4	04/30/97	04/24/97
	TOTAL DISS SOLIDS	69000.0000	68600.0000	mg/L	200.0000	77600.0000		<	10.0000	5	07/31/97	07/24/97
	TOTAL DISS SOLIDS	69000.0000	68200.0000	mg/L	400.0000	77600.0000		<	10.0000	6	03/17/98	03/05/98
	TOTAL DISS SOLIDS	60000.0000	57000.0000	mg/L	10.0000	77600.0000		<	10.0000	7	07/22/98	07/15/98
	TOTAL DISS SOLIDS	64000.0000	64000.0000	mg/L	10.0000	77600.0000		<	10.0000	8	03/03/99	03/03/99
	TOTAL DISS SOLIDS	59000.0000	61000.0000	mg/L	10.0000	77600.0000		<	10.0000	9	09/02/99	09/01/99
	TOTAL DISS SOLIDS	260000.0000	240000.0000	mg/L	10.0000	77600.0000		<	10.0000	10	03/08/00	03/02/00
	TOTAL DISS SOLIDS	65000.0000	65500.0000	mg/L	10.0000	77600.0000				10	06/20/00	03/02/00
	TOTAL DISS SOLIDS	57000.0000	##### 6900	mg/L	10.0000	77600.0000		<	10.0000	11	09/12/00	09/07/00

Baseline WQSP-1 Total Dissolved Solids

Mean	69100
Standard Error	1492.425319
Median	67650
Mode	66300
Standard Deviation	4719.463246
Sample Variance	22273333.33
Kurtosis	0.563640433
Skewness	1.237781474
Range	14100
Minimum	63500
Maximum	77600
Sum	691000
Count	10
Confidence Level(95.0%)	3376.103199



USE old 95% 77,600

WQSP-1 Total Organic Carbon

CAS #	PARAMETER	VALUE	VALUE DUPLICATE	UNITS	MINIMUM DETECTION LIMIT	95TH UTLV	ACID BLANK (AVERAGE)	WATER BLANK (AVERAGE)	ROUND #	DATE ANALYZED	DATE SAMPLED
	TOTAL ORGANIC CARBON	1.4900	1.4700	mg/L	0.5000	2.3700		< 0.5000	1	08/18/95	08/17/95
	TOTAL ORGANIC CARBON	1.3300	1.2900	mg/L	0.5000	2.3700		< 0.5000	2	04/17/96	04/11/96
	TOTAL ORGANIC CARBON	1.0500	1.0000	mg/L	0.5000	2.3700		< 0.5000	3	08/06/96	07/25/96
	TOTAL ORGANIC CARBON	0.9075	0.8600	mg/L	0.5000	2.3700		< 0.5000	4	05/05/97	04/24/97
	TOTAL ORGANIC CARBON	0.6545	0.7530	mg/L	0.5000	2.3700		< 0.5000	5	08/13/97	07/24/97
	TOTAL ORGANIC CARBON	< 0.5000	< 0.5000	mg/L	0.5000	2.3700			6	03/12/98	03/05/98
	TOTAL ORGANIC CARBON	< 5.0000	< 5.0000	mg/L	5.0000	2.3700		< 5.0000	7	07/23/98	07/15/98
	TOTAL ORGANIC CARBON	< 5.0000	< 5.0000	mg/L	5.0000	2.3700		< 5.0000	8	03/11/99	03/03/99
	TOTAL ORGANIC CARBON	< 1.0000	< 1.0000	mg/L	1.0000	2.3700		< 1.0000	9	09/13/99	09/01/99
	TOTAL ORGANIC CARBON	0.8000	0.8000	mg/L	1.0000	2.3700		< 1.0000	10	03/13/00	03/02/00
	TOTAL ORGANIC CARBON	< 1.0000	< 1.0000	mg/L	1.0000	2.3700		< 1.0000	11	09/13/00	09/07/00

Baseline WQSP-1 Total Organic Carbon	
Mean	1.0805
Standard Error	0.094294633
Median	1.025
Mode	#N/A
Standard Deviation	0.298185811
Sample Variance	0.088914778
Kurtosis	-1.449488584
Skewness	0.123644378
Range	0.8355
Minimum	0.6545
Maximum	1.49
Sum	10.805
Count	10
Confidence Level(95.0%)	0.213309442