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September 26, 1988

Mr. Michael Burkhart
Director
Environmental Improvement Division
P.O. Box 968
Santa Fe, NM 87504-0968

Dear Mr. Burkhart:

Enclosed is a copy of my testimony on September 23, 1988, before the Radioactive and Hazardous Materials Committee of the New Mexico Legislature, concerning the status of the WIPP Land Withdrawal Bill and EEG update.

Sincerely,

Jim W. Kenney for

Robert H. Neill
Director

RHN:ss

Enclosure

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Radioactive and Hazardous Materials Committee

New Mexico Legislature

Status of WIPP Land Withdrawal Bill and EEG Update

by

Robert H. Neill

Director

September 23, 1988

Mr. Chairman, Members of the Committee:

Thank you for the invitation to provide an update on the status of EEG's work on the WIPP Project.

I would like to introduce two new EEG staff members here in Carlsbad. Dr. Bill Bartlett, Health Physicist, and Ms. Sally Ballard, Environmental Technician. You all know Mr. Jim Kenney, the Carlsbad Office Manager, and Mrs. Brenda West, Administrative Officer. This brings us to 6 1/2 positions here and we are recruiting for another health physicist.

WIPP LAND WITHDRAWAL BILL

Since the update provided to your Committee in July 28, 1988, there have been a number of developments.

On the Senate side, Substitute S.1272 cosponsored by Senators Jeff Bingaman and Pete Domenici was approved by the Senate Energy and Natural Resources Committee. Last week both Senators recommended additional measures to strengthen the EEG overview functions.

On the House side, Substitute H.R.2504 sponsored by Congressman Richardson was adopted by the House Interior and Insular Affairs Committee. The Subcommittee on Energy and Power, Committee on Energy and Commerce held hearings on September 8th on H.R.2504. The following were specific comments contained in my testimony before the Subcommittee on various provisions of H.R.2504.

Section 104 - Experimental Programs

Requiring the Department of Energy to publish their proposed plans for experiments at WIPP in consultation with NAS, EPA, and EEG makes good sense as well as the requirement for EEG to publish its analyses of the DOE plans.

Section 105 - Compliance with EPA Standards

The bill is silent on EEG's role in determining compliance with the EPA standards for storage and disposal of TRU wastes and we believe the bill should require EEG to make a determination of compliance and publish the results.

Ability to Invoke Conflict Resolution

We believe that EEG should be provided the authority to invoke conflict resolution on matters relating to health and safety as stated in the substitute amendment to H.R.2504 adopted by the House Committee on Interior and Insular Affairs since there is no technical regulatory authority over WIPP. The exemption by Congress of NRC licensing for the disposal of defense transuranic waste (WIPP) is inconsistent with the requirement by Congress for NRC licensing of the disposal of both defense uranium mill tailings and defense high level wastes. Since EEG is the only full-time review agency on the WIPP Project, there should be some authority.

Limitation on Radioactive Waste

The Department of Energy has indicated that their determination of compliance with the EPA standards for the disposal of TRU and High Level Wastes (Subpart B, 40 CFR 191) will not be completed until 1993 and that WIPP will be a facility for operational demonstration and research and development during the first five years. To date, only one experiment has been identified which would measure gas generated from CH-TRU waste to be emplaced in five rooms. That would amount to less than 3% of the total waste volume (approximately 25,000 drums). We expressed our dissatisfaction in a July 13, 1988 letter to DOE on the lack of merit of this experiment and questioned whether data would be available from the five rooms for performance assessment analysis since the cutoff point for data is mid 1991.

No experiments have been identified for the RH-TRU waste which comprises 36% of the radioactive inventory nor are there any estimates of the needs for operational activities and testing.

High Level Waste Experiments

We believe that H.R.2504 should be amended to exclude high level waste experiments as required in the substitute amendment S.1272 for the following reasons:

1. No need. Since Congress eliminated salt as a medium for disposal of HLW in the December 1987 amendments to the Nuclear Waste Policy Act, there is no technical merit in studying the disposal of HLW in salt.

2. No applicability to TRU waste. Results of HLW experiments would not be particularly applicable to RH-TRU disposal since there are differences in the geometry of the packages, the fission product inventory, concentrations, waste form, thermal gradients, and geochemistry. Besides, DOE has not identified any experiments requiring RH-TRU at WIPP during the five-year Research and Development (R & D) period.

3. Radiological risk. Since some of the experiments may be conducted with bare waste in which the integrity of the canister is intentionally compromised, there is a radiological risk associated with the emplacement and retrieval. There may be complications associated with NRC licensing for the transportation of such material.

4. Little economic benefit. A dozen shipments of HLW would have little economic impact in a sea of 25,000 shipments scheduled for TRU waste.

5. Not required for HLW disposal. The DOE is not planning on conducting HLW experiments in support of disposal of HLW in the repository in Nevada nor does NRC require such experimentation for a license.

6. Not required by Congress. High level waste experiments were not required in the authorizing legislation for WIPP (PL 96-164).

7. Benefits not published. DOE has never published any plans for the information to be derived, applicability of the results, and economic or technical benefits to justify the transportation and experimentation with

17 million curies of HLW with a maximum external gamma dose rate of 30,000 rem per hour.

8. DOE Inspector General recommended cancellation. The DOE Inspector General's 1984 report recommended that the experiments be cancelled because of their limited usefulness.

Congressman Bill Richardson presided at the Subcommittee Hearing on September 8, 1988, and asked the DOE, EPA, and EEG representatives to meet and try to reach an agreement on the amount of waste that may be brought to WIPP before demonstrating compliance with the EPA disposal standards (40 CFR 191, Subpart B). I met with EPA and DOE on the 9th and Lokesh Chaturvedi and I met with DOE on the 13th and 14th. The negotiations did not yield a satisfactory compromise because DOE officials maintained that they need to bring more than 3% of the total waste before showing compliance with the EPA standards. As you know, the Bingaman/Domenici substitute S.1272, WIPP Land Withdrawal Bill, approved by the Senate Energy and Natural Resources Committee, allows up to 3% and the Richardson H.R.2504 substitute approved by the House Interior and Insular Affairs Committee allows none. Our discussions with DOE headquarters officials did provide an opportunity to discuss the technical aspects of this issue and the meetings were constructive and cordial.

The Subcommittee on Procurement and Military Nuclear Systems, Armed Services Committee also held hearings on September 8th. Hence, three different House Committees have held legislative hearings on the WIPP land withdrawal.

In addition, Dr. Lokesh Chaturvedi testified at a September 13th oversight hearing on WIPP held by the Subcommittee on Environment, Energy and Natural Resources of the Committee on Government Operations chaired by Congressman Mike Synar and a copy of his testimony is attached. A representative of the General Accounting Office (GAO) testified and three memoranda from the DOE Office of Safety Appraisals and their contractor, Brookhaven National Laboratory, were released by the Chairman of this Subcommittee. These memos were critical of the lack of documentation on WIPP design and safety matters, as well as other WIPP related issues.

While we are examining in detail the points raised at the Synar Subcommittee hearings, the following is our initial reaction to the issues.

1. Safety Analysis Report (SAR) - EEG is reviewing a draft of the final SAR and we have many critical comments on the document. We agree with the DOE-OSA analysis that because of a lack of proper documentation of the quality assurance inspections it will take the reviewers greater effort and time consuming research to be convinced of the safety of the project design, structures and components.

2. Change of design basis - We do not think that this change by Bechtel and the lack of documentation (Brookhaven 8/25/88 letter and trip report, page 3) is a showstopper. The criticism is valid but it is now a moot point because there now exists actual data from underground excavations for five years.

3. Mixed waste - The criticism of jurisdictional uncertainty for RCRA compliance of WIPP is valid but the Senate version of the bill assigns jurisdiction to EPA until the State is in a position to take the responsibility.

4. Lack of Experimental and Operation Plan - We think that this is the most important issue on WIPP currently. DOE should publish the plans for experiments involving waste during the five year R and D period and an operational plan should also be developed and published.

OTHER EEG ACTIVITIES

RCRA Mixed Waste

About 85% of the waste slated for WIPP is defined as mixed waste and is subject to EPA licensing provision. Due to conflicting regulatory authorities, no agency is in a position today to regulate mixed wastes bound for WIPP. The Bingaman/Domenici Substitute Bill for 1272 effectively addresses this issue by having EPA take the responsibility until the State is ready to assume that responsibility.

TRUPACT Testing

While we have been a representative at virtually all of the TRUPACT tests, EEG was not invited to the most important action of determining whether the seals on both the inner (ICV) and outer (OCV) containment vessels were adequate to meet the NRC standard of a leakage rate less than 10^{-7} standard cubic centimeters per second at -20°F. According to information provided by DOE to us later, the OCV passed the test. However, the ICV did not pass the test and the reason was believed to be due to the deposition on the upper O-ring of dust and particulates from the concrete in the 14 drums that were in the ICV as a simulated payload. DOE believes that the addition of a dust shield to prevent particles from reaching the O-ring will solve this problem. Since each drum may have five pounds of respirable dust sized particulates (up to 1% by weight with particle sizes of 10 microns or less), it is essential that the problem be resolved.

Safety Analysis Report (SAR)

EEG is still reviewing the 5 volume document and we have a number of concerns about the adequacy of the document and hope to get our review to DOE within the next two weeks.

Radiation Detection Instrumentation

On May 4, 1988, EEG requested that DOE provide the test plan for review for the Continuous Air Monitoring (CAM) system to be used to detect radioactivity in air. We still do not have a complete test plan or any data that has been generated. A recent meeting to discuss this was canceled by DOE and has yet to be rescheduled. Since the CAM system monitors airborne radioactivity in the facility below ground, in the exhaust effluent, and in the waste handling building, it is imperative that this system be proven to be suitable in the several operational environments of WIPP before the plant can be considered ready to receive waste.

PRESENTATIONS/MEETINGS

Date	Name	Title	Location
9-22-87	Robert H. Neill	Idaho National Engineering Laboratory visit with NAS WIPP Panel	Idaho Falls, ID
9-22-87	Lokesh Chaturvedi	Presentation, NAS WIPP Panel, "The Backfill Issue and the First Seven Years of WIPP"	Idaho Falls, ID
9-22-87	James K. Channell	Presentation, NAS WIPP Panel, "Estimating Quantities of Radionuclides Brought to the Surface By Human Intrusion into WIPP"	Idaho Falls, ID
9-26-87	Robert H. Neill	Presentation, New Mexico Academy of Sciences	Los Alamos
9-30-87	Robert H. Neill	Presentation, High Level Waste Repository Affected States Meeting	Dallas, TX
10-12-87	Robert H. Neill Lokesh Chaturvedi James K. Channell	Testimony, U. S. Senate Subcommittee Hearings on the WIPP Land Withdrawal Bill	Carlsbad
10-15-87	Lokesh Chaturvedi	Presentation, New Mexico State University American Society of Civil Engineers, Society of Mining Engineers, and Association of Engineering Geologists, "Geotechnical Investigation at WIPP"	Las Cruces
10-28-87	Lokesh Chaturvedi	Presentation, Geological Society of America Annual Meeting, "Chairman Session on Environmental Geology"	Phoenix, AZ
11-18-87	Robert H. Neill James K. Channell	TRUPACT Design Workshop	Seattle, WA
12-15-87	Robert H. Neill	NRC TRUPACT Review Meeting	Rockville, MD

Date	Name	Title	Location
1-7-88	Robert H. Neill	Presentation, Eldorado Community Improvement Association	Santa Fe
1-13-88	Robert H. Neill	Testimony, New Mexico Radioactive Waste Consultation Task Force Meeting	Santa Fe
1-13-88	Lokesh Chaturvedi	Testimony, New Mexico Radioactive Waste Consultation Task Force Meeting, "Facts and Implications of a Wet Repository Scenario"	Santa Fe
1-18-88	Lokesh Chaturvedi	Testimony, New Mexico Radioactive and Hazardous Materials Committee Special Meeting, "WIPP Repository Brine Issue"	Santa Fe
2-7-88	Robert H. Neill	Presentation, Unitarian Church	Santa Fe
2-9-88	James K. Channell	NRC TRUPACT Review Meeting	Rockville, MD
2-18-88	Robert H. Neill James K. Channell	NAS WIPP Panel Meeting Presentation, NAS WIPP Panel Meeting, "Probability of Exceeding EPA Standards"	Albuquerque
2-24-88	Lokesh Chaturvedi	Presentation, "Geotechnical Evaluation of WIPP," Los Alamos National Laboratory	Los Alamos
2-29-88	John C. Rodgers & William E. Farthing	"Stack Discharge Monitoring Issues at the Waste Isolation Pilot Plant," Waste Management '88 Symposium	Tucson, AZ
3-1-88	Robert H. Neill	"Ten Years of State Evaluation of a Nuclear Waste Repository," Waste Management '88 Symposium	Tucson, AZ

Date	Name	Title	Location
3-2-88	Lokesh Chaturvedi, James K. Channell, & Jenny B. Chapman	"Potential Problems Resulting from the Plans for the First Five Years of the WIPP Project," Waste Management '88 Symposium	Tucson, AZ
3-24-88	Robert H. Neill	Presentation, WIPP Transportation, League of Women Voters, City of Santa Fe, Sweeney Center	Santa Fe
3-25-88	Robert H. Neill	Presentation, Land Use IV, "Hazardous Waste: WIPP in New Mexico"	Albuquerque
3-29-88	Robert H. Neill	University of New Mexico Civil Engineering Department Seminar	Albuquerque
3-30-88	Lokesh Chaturvedi	Presentation, New Mexico State University American Society of Civil Engineers, Society of Mining Engineers, and Association of Engineering Geologists Meeting, "The WIPP Repository Brine Issue"	Las Cruces
4-15-88	James K. Channell	Presentation, International Radiation Protection Association on "Experiences with Transuranic Waste Shipments in the United States"	Sydney, Australia
4-19-88	Lokesh Chaturvedi	Radioactive Waste Consultation Task Force Meeting	Carlsbad
4-27-88	Robert H. Neill	Presentation, American Water Works Association and Water Pollution Control Association	Albuquerque
5-12-88	Robert H. Neill	Testimony, Radioactive & Hazardous Materials Committee, New Mexico Legislature	Santa Fe
7-13-88	Robert H. Neill	Presentation, Rotary Club	Carlsbad
7-20-88	Robert H. Neill	Presentation, Channel 2	Santa Fe

Date	Name	Title	Location
7-22-88	Robert H. Neill	Presentation, Radiation Technical Advisory Committee	Carlsbad
7-28-88	Robert H. Neill	Testimony, "WIPP Land Withdrawl Bill - Update," New Mexico Legislature, Radioactive & Hazardous Materials Committee	Santa Fe
8-3-88	Robert H. Neill	Presentation, Radioactive Waste Consultation Task Force	Albuquerque
9-8-88	Robert H. Neill	Testimony, Hearing on H.R.2504, the WIPP Land Withdrawl Act, Subcommittee on Energy & Power, Committee on Energy & Commerce, U.S. House of Representatives	Washington, DC
9-13-88	Lokesh Chaturvedi	Testimony, "Analysis of the Status of WIPP," Environment, Energy & Natural Resources Subcommittee, Committee on Government Operations, U.S. House of Representatives	Washington, DC
9-17-88	Robert H. Neill	Presentation, "Nuclear Waste Storage and Cleanup," Trinity Forum, St. Johns College	Santa Fe

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An Analysis of the Status of WIPP

Invited Testimony

by

Lokesh Chaturvedi

Deputy Director, EEG

to

Environment, Energy and Natural Resources Subcommittee

of the

Committee on Government Operations

U. S. House of Representatives

September 13, 1988

Mr. Chairman, Members of the Subcommittee:

Thank you for the opportunity to testify on the Environmental Evaluation Group's (EEG) analysis of the status of WIPP. In my testimony, I will confine myself to brief remarks on the issues that you have raised in your letter of September 2, 1988, to me. I will, of course, be glad to discuss any of these issues further in clarification of my remarks.

Background of EEG

I believe it will be helpful to you if I took some time to give you a background of the organization that I have been a part of since 1979 and that I represent today. EEG was established to provide an independent technical evaluation of the Waste Isolation Pilot Plant (WIPP) project to the State of New Mexico with funds provided by the U. S. Department of Energy (DOE). The multidisciplinary group of eight scientists and engineers has been performing this evaluation to assess the suitability of the WIPP site, potential short and long-term danger to the environment, suitability of the plant design, suitability of the container that will be used for transporting the waste over the nation's highways, acceptability of the waste from various generator sites, and related matters. We have published the results of our analyses and recommendations for improvement through EEG reports, thirty-nine to date, and in the open scientific literature. Three years ago, we started monitoring the environment near the WIPP site for background radioactivity in the air, water and soil. We will continue this monitoring, on-site and off-site, when the radioactive waste starts arriving at WIPP, to detect and measure any releases that occur.

EEG's philosophy has been to be constructive in its criticism and I am happy to report that DOE has accepted most of our major suggestions during the past ten years, ranging from a relocation of the repository to a redesign of the shipping cask for the transuranic waste. In spite of the dislocation and loss of some key personnel caused by unfortunate events of the past year, our small group has maintained its effectiveness and scientific integrity. We remain committed to continue our work to find an environmentally acceptable solution to the nation's defense transuranic radioactive waste problem.

I will now address the issues that you wish to discuss today.

1. Status of DOE's five-year plan for WIPP and the need for experiments requiring waste emplacement

The DOE describes WIPP as a Research and Development facility, but we have not been able to receive a final plan of research requiring waste emplacement at WIPP to date. After many reminders from us during the past several years, we received the first draft of a five-year plan that contains only four pages of an outline of an experiment that requires emplacement of waste underground. EEG expressed concerns about the validity of these experiments in a letter to DOE dated July 13, 1988, but we have not yet received a reply from DOE. We are concerned that if a large amount of waste is emplaced underground without simultaneously emplacing backfill material around and over the drums, there will be an unnecessary shuffling of the drums underground for backfill emplacement later. In addition, there is a possibility of DOE deciding in favor of reprocessing the drums (compaction, cementation, or glassification) to be in compliance with the EPA Standards.

In that case, the drums will have to be brought to the surface for reprocessing before final emplacement. The wisest course, therefore, seems to be to emplace a large quantity of waste underground only after a decision on reprocessing has been made and a backfill material has been selected. It is necessary to complete the calculations of "performance assessment" (to show compliance with Subpart B of the EPA Standards, 40 CFR 191) to make a decision on the selection of these "engineered barriers." My underlying assumption in the preceding statement is that WIPP will be able to comply with the EPA Standards with the addition of more stringent "engineered barriers" in the design. If that assumption is found to be incorrect, it would make even more sense to not have to retrieve a large quantity of waste from the repository.

2. The repository brine issue and the possible presence of brine reservoir below WIPP

These two issues relate to the possibility of a breach of the repository hundreds or thousands of years in the future.

Repository Brine:

The "repository brine issue" is that the salt formation in which the WIPP repository is located, appears to be saturated with brine that will slowly move into the excavations and may form a "slurry" of brine and waste in a few hundred years after closure of the repository. Calculations performed by the scientists at Sandia National Laboratories (SNL) in 1987 concluded that, given the best-known inventory of WIPP waste, the rates of brine inflow, gas generation and salt creep, between 5 and 15 m^3 (1300 to 4000 gallons) of "slurry" of brine and waste released to the surface will violate the EPA Standards. These calculations were presented and discussed at a meeting of the National Academy of Sciences Panel on WIPP in September, 1987. Revised calculations published by SNL this year indicate that there would not be sufficient brine seepage to form a slurry before the waste and backfill is compacted due to salt creep. Because of the uncertainties in these calculations, EEG recommended more in situ measurements of permeability of WIPP salt and direct measurements of brine inflow in a specially designed room underground. These experiments are being performed now. In addition, we have recommended consideration of reprocessing of the drums to reduce the void volume in the repository and DOE is examining that option.

Brine Reservoir:

The WIPP repository is located in the lower part of a 2000 ft. thick geological formation known as the Salado Formation. The Salado extends from approximately 850 ft. to 2825 ft. below the surface at the WIPP site and the repository is located at 2150 ft. below the surface. The approximately 1250 ft. thick Castile Formation underlies the Salado Formation, starting at a depth of 2825 ft. Within ten miles of the WIPP site, there have been thirteen reported encounters of pressurized brine in the upper anhydrite layer of the Castile Formation. An encounter typically consists of artesian flow of several hundred gallons a minute of brine at the surface. The first selected site for WIPP was abandoned in 1975 when the first WIPP borehole (ERDA-6) encountered brine. In 1981, another borehole (WIPP-12) was deepened at the suggestion of EEG, and it too encountered pressurized brine at

3000 ft. below the surface. Further testing estimated the reservoir encountered by this borehole to contain 700 million gallons of brine. Since the WIPP repository as designed at the time would have been only 500 ft. south of WIPP-12, the site was again relocated southwards so that the nearest waste emplacement would be more than one mile south of WIPP-12.

In 1983, EEG recommended surface-based geophysical exploration to attempt to delineate the extent of the brine reservoir encountered by WIPP-12. DOE performed this study in 1987 and the results show that brine appears to be present about 800 ft. below portions of the present repository location.

It is essential that consequence analyses of breach scenarios involving a pressurized brine reservoir under the repository be performed and published as soon as possible. This will be a necessary part of the calculations to determine WIPP's ability to comply with the EPA Standards.

3. Other items which must be resolved on WIPP prior to the receipt of radioactive waste

◊ The TRUPACT needs to be certified by the Nuclear Regulatory Commission. We are closely following the testing and the certification process and will perform our own evaluation of its adequacy.

◊ The Continuous Air Monitoring system which provides a current measurement of the concentrations of radioactivity in the atmosphere of the Waste Handling Building and underground is still not operational. An earlier design of this system has been modified as a result of deficiencies pointed out by EEG. However, the present system has still not been thoroughly tested to indicate that it will be able to measure the low concentrations of TRU radioactivity required in the presence of atmospheric salt particles and background radioactivity from radon daughter products.

◊ Two major facilities at the site are not yet completed. These include the air intake shaft and the Safety and Emergency Services Facility building, both of which are expected to be completed by January 1989.

Mr. Chairman, this completes my prepared statement. I will be happy to respond to any questions.

TEN YEARS OF STATE EVALUATION OF A NUCLEAR WASTE REPOSITORY

Robert H. Neill
Environmental Evaluation Group
State of New Mexico
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ABSTRACT

The Environmental Evaluation Group (EEG), was established in 1978 to independently evaluate the Waste Isolation Pilot Plant (WIPP) project for the State of New Mexico in order to protect the public health and safety and ensure that there is minimal environmental degradation from the project. In October, 1988, WIPP will become the first engineered geological repository to dispose of nuclear waste. By concentrating on objective technical evaluation, the EEG has been able to improve the location, design, operations and safety of the project. The evaluation has consisted of independent analyses of scientific data on site characterization, breach scenario modeling, transportation risks and safety, design parameters, operational risks and safety, waste certification, and mining. The U. S. Department of Energy (DOE) has accepted EEG's suggestions on site relocation, transportation cask redesign, limitations on the kind of waste allowed at WIPP, waste certification procedures, additional site characterization, compliance with regulatory standards, operational procedures, and radiological monitoring. EEG's work has also helped in providing a proper perspective and sound foundation to the sometimes emotional debate on actual or perceived risks from a highly visible project. It has thus been possible to resolve contentious issues based on scientific investigations and analyses. As WIPP moves into an operational phase in 1988, EEG will continue to closely monitor the health and safety aspects of the project.

INTRODUCTION

The review and evaluation by the New Mexico Environmental Evaluation Group (EEG) of the proposed WIPP Project was established in the fall of 1978. The State had identified a number of concerns relating to the impact of the project on the health and safety associated with the transportation, emplacement and potential breach and release of radioactive wastes to the environment. The U. S. Department of Energy (DOE) agreed to fund an independent review and the following describes some of the principal findings by EEG.

ORGANIZATION

Since the focus of the work relates to protection of the public health, the EEG was administratively attached to the Environmental Improvement Division of the Health and Environment Department, which is the agency in New Mexico with the primary responsibility to protect the public health and avoid environmental degradation.

STAFFING PATTERNS

The decision was made in 1978 to employ full-time staff in order to achieve long-term continuity for accountability as well as historical knowledge of issues that evolve over a period of time and not rely on contracts with various firms for specific pieces of work. Because the New Mexico State salary structure was below existing patterns in industry and the federal government, DOE was willing to fund the appointment of staff based on the federal salary structure to insure senior knowledgeable scientists and engineers with a breadth and understanding of the impact of radiation exposure on the public health. From the beginning, EEG maintained a strong radiation protection capability as well as a strong competency in the geological sciences. While the initial makeup included a mathematician, later appointments included expertise in environmental surveillance, quality assurance and on-site health physics. Staff members have had to function in areas besides their primary expertise and this has had a salutary influence on the necessary interactive efforts of the multi-disciplinary staff. Consultants have been used in specific areas such as criticality, mining engineering, geochemistry, hydrogeology, rock mechanics, electrical systems, and aerosol technology for stack discharges .

FUNDING

The EEG contract has been funded totally by the DOE. While we expected criticism that our analyses would be biased in favor of the source of the funding, there has been very little concern over the years along those lines. It is generally recognized that the expense of a radiation exposure review of the TRU-Waste repository for the nation's weaponry program should not be borne by New Mexico exclusively but should be shared by all 50 states through federal funding.

COMMUNICATION OF RESULTS

A vital part of the EEG effort is communicating the results of our investigations to the scientific community and the public at large. Thirty-seven major reports (list attached) have been published and distributed to 450 recipients. The Group's credibility and the strength of our recommendations are enhanced by the process of peer review. Critiques of DOE reports accounted for 6 reports and original work for the other 31. Examples of scientific presentations include papers at conferences held by the American Chemical Society, American Nuclear Society, American Public Health Association, American Society of Civil Engineers, Association of Engineering Geologists, Atomic Industrial Forum, Geological Society of America, Institute of Nuclear Materials Management, Health Physics Society, and of course the Waste Management Symposia. Policy makers and technical advisors have heard from EEG through presentations to the Radioactive and Hazardous Waste Committee of the New Mexico Legislature, Committees of the U. S. Congress, and the Radioactive Waste Task Force consisting of four Cabinet secretaries. Other presentations include the Nuclear Regulatory Commission (NRC), the National Academy of Sciences (NAS) WIPP Panel, the Western Interstate Energy Board, and DOE/States Meeting on the HLW repository. In addition, the general public has been briefed at public meetings and through university presentations.

SITE CHARACTERIZATION

The major effort by EEG over the years has been in the area of site characterization work and 16 major reports have been published evaluating the adequacy of the site characterization studies. In trying to predict the geological performance of the site in the distant future, EEG sponsored meetings and a field trip to address geologic and hydrologic mechanisms that might lead to the release of radionuclides from the WIPP repository. We invited knowledgeable experts from federal and state agencies, the NAS WIPP Panel, and several universities in the State to try and obtain some type of agreement on the impact of such processes and the manner in which they might be resolved. While consensus is far too optimistic a term due to the disparity of views on predictions of long-term effects, the sessions did approach reasonable closure on a number of issues.

The determination by EEG in 1983 that the site had been characterized in sufficient detail to warrant confidence in the validation of the site for the permanent emplacement of defense transuranic waste was based primarily on an understanding of the geohydrological regime and not through quantification of the radiological risks. At that time, EEG requested DOE to perform a number of additional geological and hydrological studies which were subsequently implemented by DOE.

TRANSPORTATION

Major efforts by EEG in 1979 and 1980 were directed towards predicting radiation doses from normal and accidental releases of radioactivity in the transportation of wastes to WIPP via truck and rail. In 1983 we published analyses related to transportation problems from the radiolytic generation of hydrogen and other gases during shipment of high curie content CH-TRU waste to WIPP.

Considerable attention was directed by EEG in a report issued in 1986 to the inadequacy of the rectangular TRUPACT-I design for transporting CH-TRU wastes to WIPP. The vented design with single containment did not meet regulations for the transportation of shipments of plutonium exceeding 20 curies that had been issued by the Atomic Energy Commission (AEC), Nuclear Regulatory Commission (NRC), and DOE. EEG provided testimony on DOE's request to a) ANSI to develop a less restrictive standard for double containment and venting, b) DOE Headquarters to certify the rectangular TRUPACT design, and c) DOT to ease the requirements in 49CFR173 to comply with the NRC 10CFR71 regulations in this area. In 1986, the Albuquerque Operations Office (ALO) announced the redesign of the shipping container to meet the two requirements. Subsequently in 1987 the rectangular design was abandoned in lieu of a right circular cylinder container scheduled to carry 14 drums on two levels.

National accident statistics lead to the prediction there would be only 0.2 release accidents during the lifetime of WIPP (in all states). However, there would be about 41 accidents during the 24,000 shipments.

MONITORING PROGRAMS

A preoperational environmental surveillance program for radioactivity has been established for the past two years to obtain on-site and off-site background measurements for radioactivity in air, water, soil, and biota. Analyses include ^{238}Pu, $^{239+240}Pu$, ^{3}H, ^{137}Cs, ^{241}Am, ^{226}Ra, ^{228}Ra, and ^{90}Sr.

DOE has also agreed to permit independent measurements by EEG for radioactivity in the exhaust air from the mine.

In early 1988, EEG published an analysis and evaluation of the DOE isokinetic monitoring system in the exhaust air which is being covered in another paper.

DOSAGE ESTIMATES

Attention has been focused on quantifying potential radiation exposure to people from transportation, long-term releases and operations. Seven reports have been issued assessing the potential radiation doses associated with brine reservoirs, breccia pipes, extraction of minerals, use of contaminated well water, and transportation of radioactive wastes.

QUALITY ASSURANCE

DOE has established a Coordinating Committee to insure that the waste generators conform to the Waste Acceptance Criteria for WIPP. EEG provides an observer on all field trips to the generating sites to help insure compliance with these criteria. Our on-site quality assurance (QA) engineer provides an overview of all conventional QA requirements.

UNIQUE ASPECTS OF WIPP

There are a number of unique aspect to WIPP that have made the work of EEG challenging.

1. Elimination of NRC licensing. Congress excluded NRC licensing of WIPP in the 1979 Authorization Act. (PL 96-164). As the following table indicates there appears to be an apparent inconsistency by Congress in requiring NRC licensing for the 3 different types of radioactive defense wastes.

<u>Disposal of Radioactive Defense Wastes</u>

	NRC Licensing
Uranium Mill Tailings	Yes
TRU	No
High-Level Wastes	Yes

In effect, WIPP is akin to an AEC type project in which the same agency has the responsibility to proceed with the development of the repository and to also determine its degree of safety. This places a very heavy burden on EEG to insure that the States' health and safety concerns are fully met.

2. No veto power. While Congress provided this power to the Governor and Legislature for States under NWPA, it was denied New Mexico. The original commitment of veto power to New Mexico eroded to consultation and concurrence and subsequently to consultation and cooperation.

3. Standards for disposal. Since standards for the disposal of TRU Waste (40CFR191) were not promulgated by Environmental Protection Agency (EPA) until 1985, the evaluation of the post-closure radiological risks of WIPP were conducted by DOE, Sandia and EEG in 1979 and 1980 using reasonable worst case scenarios for consequence analyses and additional scenarios were also published by EEG through 1982. In May 1983 EEG concluded that the site had been adequately characterized for the emplacement of transuranic waste and DOE proceeded with excavation for the WIPP repository.

The September 1985 EPA standards were subsequently vacated in July 1987 by the First Circuit Court in Boston because certain features were not sufficiently restrictive and the agency had failed to follow established rule making procedures. New Mexico entered into an agreement with DOE in July to proceed with an evaluation of conformance of WIPP with the vacated standards. This was considered logical since it is expected that the bulk of the Disposal Requirements (Subpart B) would be salvaged in the re-promulgation which is currently expected to take several years. DOE's schedule for completion of the demonstration of compliance with the Disposal Requirements will occur in 1992. Waste is scheduled to begin arriving in October, 1988.

4. Changes in inventory. The inventory of radioactive waste materials indentified in the April 1979 WIPP Draft Environmental Impact Statement was estimated as follows:

April 1979

Waste Type	Curies
CH-TRU	$3.4x10^6$
RH-TRU	$3.0x10^6$
High-Level Waste	$9\text{-}90x10^6$

- o Congress deleted the permanent emplacement of 1000 spent fuel assemblies in the January 1980 authorizing legislation for WIPP. The inventory of waste identified in the October 1980 WIPP FEIS was

October 1980

Waste Type	Curies
CH-TRU	$2.8x10^6$
RH-TRU	$5.1x10^6$
HLW	$17x10^6$

- o Subsequently, the definition of the lower limit of TRU waste was raised from 10η Ci/g waste to 100η Ci/g waste.

The most recent inventory contained in the 1987 DOE compilation shows a substantial increase in CH-TRU waste.

1987		
Waste Type	Curies	Intended Use
CH-TRU	$9.4x10^6$	Permanent Emplacement
RH-TRU	$5.1x10^6$	Permanent Emplacement
HLW	$17x10^6$	Temporary Experiments

ACCOMPLISHMENTS

What are some of the accomplishments of the EEG efforts? Since the State does not have regulatory authority, reliance has been placed on convincing DOE of the merit of our arguments in an interactive manner.

1. Relocation of the repository. After a brine reservoir estimated to be 5 to 17 million barrels was intercepted at a point 460 feet north and 600 feet below the planned location of radioactive waste, EEG recommended the relocation of the repository 1-1/4 miles to the south to a zone that was structurally less complex. Eight months later, DOE concurred.

2. DOE agreed to conduct additional tests to flow a brine reservoir, delineate the extent of brine under the repository through geophysical techniques and to measure the flow and transport characteristics of the aquifer most likely to be involved in a breach scenario.

3. After EEG notified DOE in August 1985 that the design of the TRUPACT-I shipping container to be used to transport transuranic wastes to WIPP was unacceptable for use in New Mexico, DOE agreed in May 1986 to redesign the shipping container to incorporate U. S. Nuclear Regulatory Commission requirements of double containment for shipments exceeding 20 Ci Plutonium and to eliminate venting. Subsequently, DOE has agreed to have all shipping containers used to bring waste to WIPP certified by the Nuclear Regulatory Commission.

4. EEG sponsored 5 major meetings providing a forum for differing views on the adequacy of the geology to prevent the waste from returning to the biosphere and to quantify the radiation doses from different breach and leach scenarios. While these sessions did not achieve a technical consensus, they did approach agreement on the information needed to be able to predict long-term future behavior based on reconstruction of the past history. Credit for these very successful sessions is also shared with DOE and Sandia, the U. S. Geological Survey, the National Academy of Sciences and universities of New Mexico and other universities. It is essential that technical concerns be aired through structured scientific debate, not only to try and resolve their future significance but to provide assurance to policy makers and the public that these issues are being openly and adequately addressed.

5. Continuing technical interactions with DOE to insure a good system. An example is the work this past year to have DOE redesign the monitoring system in the exhaust air duct from the mine to detect radioactivity during operations.

6. Recommended reincluding the 4th shaft for air circulation in the repository.

WORK TO BE DONE

Some of the major challenges to be addressed this year include:

1. Evaluation of the design of the new Type B TRUPACT shipping container to be used for the transportation of Contact Handled Transuranic waste and the RH-TRU Waste shipping cask.

2. Completion of the EEG preoperational monitoring program at the site and in the surrounding communities and conversion to an operational system.

3. Complete our evaluation of DOE's on-site continuous air monitoring systems.

4. Evaluation of the air underground ventilation system for both normal and accidental conditions for the new air intake shaft scheduled for completion in October 1988.

5. Complete our evaluation of WIPP's compliance with Part A of the EPA Standard relating to management and storage (Part A, 40CFR191) and evaluate DOE's determination of compliance.

6. Evaluate the DOE plans for CH-TRU and RH-TRU experiments at WIPP when published.

7. Revise estimates of waste hoist system failures.

8. Evaluate the results of Site Characterization Studies that have been performed since 1983 before waste begins to arrive in October, 1988.

9. Integrate information from ongoing studies to assess compliance with the Containment Requirements of Part B of the EPA Standards.

CONCLUSIONS

The overview of the WIPP Project by the New Mexico EEG has resulted in improvement in the safety of the Project, airing of key issues, public recognition of the magnitude of the radiological risks and their acceptability, and lastly, credibility in the scientific process by studiously avoiding either a pro or anti posture in conscientiously addressing the problems.

While much work still needs to be done including the determination of compliance with the EPA Standards for disposal, (to be re-promulgated in the next few years), the efforts have been a resounding success. Credit also needs to be given to the individuals who had the foresight in 1978 to establish EEG. They include George Goldstein and Tom Baca for the State of New Mexico and Herman Roser and Don Schueler of DOE.

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POTENTIAL PROBLEMS RESULTING FROM THE PLANS FOR THE FIRST FIVE YEARS OF THE WIPP PROJECT

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ABSTRACT

The Waste Isolation Pilot Plant (WIPP) in southeastern New Mexico is scheduled to start receiving defense transuranic (TRU) wastes in October, 1988. The U. S. Department of Energy (DOE) has planned to store up to 126,000 drums of contact-handled (CH-TRU) waste without backfill during the first five-year period. This waste will have to be removed and restacked with backfill during the next 10 years while new waste will be arriving for disposal. To make matters more complicated, it appears that the existing drums of CH-TRU waste have too much void space and since the drums are expected to become corroded in a few tens of years, the brine issuing from the salt walls may form a slurry of waste in a few hundred years after closure. Preliminary calculations indicate that such conditions may violate the EPA Standards (40 CFR 191.13) on the basis of analyses of human intrusion scenarios. DOE does not plan to complete the performance assessment work to assess WIPP's compliance with the EPA Standards until 1993. If the waste drums and boxes have to be reprocessed to reduce void space in them and the backfill is redesigned to include cement or chemical grout mixtures instead of the presently planned salt/bentonite mixture, each drum may have to be brought up to the surface for reprocessing and taken down again for final disposal. It would be simpler and less hazardous to emplace substantial quantities of waste underground only after the decisions about any needed reprocessing of the waste drums and the design of backfill have been finalized.

INTRODUCTION

The Waste Isolation Pilot Plant (WIPP) is a repository for the disposal of transuranic (TRU) wastes resulting from defense activities of the U.S. Government. The Public Law (P.L. 96-164, 1979) authorizing WIPP exempted it from licensing by the Nuclear Regulatory Commission (NRC). The repository has been designed to dispose 156,000 cubic meters (5.5 million cu. ft.) of contact-handled transuranic (CH-TRU) waste and 4250 cubic meters (150,000 cu. ft.) of remote-handled transuranic (RH-TRU) waste. In addition, the U. S. Department of Energy (DOE) plans to emplace 28 cubic meters (1000 cu. ft.) of defense high-level waste (HLW) for experiments. The HLW will be retrieved before decommissioning the repository. DOE plans to start shipping the TRU waste to WIPP in October, 1988 and has designated the first five-year period of operations as the Research and Development (R&D) phase. While an NRC license is not required for WIPP, the facility must comply with the "Environmental Radiation Protection Standards for Management and Disposal of Spent Nuclear Fuel, High-Level and Transuranic Radioactive Wastes" promulgated by the Environmental Protection Agency (EPA) and contained in 40 CFR 191.

In the absence of NRC regulatory authority over WIPP, the State of New Mexico's Environmental Evaluation Group (EEG) provides the only full-time technical review and oversight of the WIPP project. The EEG consists of a group of eight scientists representing the disciplines of geology, hydrology, health physics, environmental engineering, and environmental monitoring, and has been in existence since 1978 with funds provided by DOE to the State of New Mexico. The evaluation by this group has resulted in several recommendations for changes in the plans or for additional studies to resolve questions of the long- and short-term safety of the project. These recommendations have generally been accepted by DOE.

While DOE has designated the WIPP Project as a R&D facility for the first five years (1988-93) of operations, the R&D plans that would require waste to be emplaced underground have not yet been published. Nevertheless, DOE plans to emplace up to 126,000 drums of CH-TRU waste underground in an easy retrieval mode for the first five-year period. It now appears that this temporarily stored waste will not just have to be removed for proper emplacement with backfill, it may have to be reprocessed before re-emplacement for disposal in order to be in compliance with the EPA Standards.

The WIPP repository is located in southeastern New Mexico, 40 km east of Carlsbad, New Mexico (Fig. 1) at a depth of 855 meters in the lower part of a 600-meter thick salt formation known as the Salado Formation (Fig. 2). The presently planned size of the repository is about 50 hectares, located within an 800 hectare area that has been reserved for future expansion. The repository will consist of 8 "panels" with 7 "rooms" (300 ft x 33 ft x 13 ft) in each panel (Fig. 3). CH-TRU waste will be emplaced in 55-gallon drums stacked 3 high in the rooms and in the drifts connecting the rooms and in boxes. RH-TRU waste will be disposed in 36-inch diameter horizontal holes in the walls of most of the rooms. Three vertical shafts, the experimental areas north of the shafts, access drifts to the repository including one drift (E140) to the southern edge of the repository, and two rooms in Panel 1 (northeast panel) have been excavated. Before decommissioning in the year 2006, each panel entry through the two east-west drifts will be plugged and sealed. Entry to each room is not planned to be sealed since the approach drifts will also be used for disposing the CH-TRU waste.

RETRIEVABILITY AND BACKFILL

The concept of maintaining easy retrievability for the WIPP waste for five years after first emplacement has been a part of the WIPP design since 1980 (1). Since the retrieval of waste emplaced for the first five years would require 5 to 10 years after the decision to retrieve is made, prediction of "room" conditions for up to 15 years after excavation is needed. Before underground excavation at WIPP, the predicted rate of room closure was such that a 13-ft. high and 33-ft. wide room would not undergo sufficient plastic deformation to threaten crushing and breaching of the drums for at least 15 years. Salt deformation rates measured in the WIPP excavations were, however, found to be 3 to 5 times larger than the computed values (2). In spite of detailed investigations of the halite parameters, the reason for this discrepancy remains unresolved (3). Figure 4 shows the large difference between the predicted and the measured roof-to-floor closure of test rooms 1, 2, 3, and 4 (see Fig. 3 for location of these rooms northwest of the shafts). The test rooms were excavated to be the same dimensions as the actual repository rooms. The observed higher rates of salt creep would not allow easy retrievability of 5 years of waste and a careful analysis of the situation in 1986 resulted in 5 design modification options (4) as follows:

1. Reduce the volume of waste to be stored, retain backfill and retrieve within 7 years of excavation.

2. Use no backfill, retain the original volume of waste, but retrieve within 7 years of excavation.

3. Excavate the rooms to 14 x 34 feet and trim again to that dimension after one year. Complete retrieval within 6 years of initial excavation. Allow crushing and breaching of the CH waste containers before retrieval if backfill is emplaced.

4. Reduce creep rate by reducing the room width from 33 ft to 28 ft. This would require reducing the pillar width between the rooms from 100 ft to 84 ft to accommodate the same volume of rooms within the repository area. Emplacement of backfill would be allowed under this option. This alternative would require additional engineering evaluations.

5. Make no changes in the planned room dimensions, waste volume, and backfill requirement, but allow crushing and breaching of the waste drums prior to their retrieval.

The analyses presented in the Design Validation Final Report (4) made it clear that unless the facility is to be completely redesigned in view of the observed higher rate of salt creep, it would not be possible to retrieve the waste emplaced during the first five years without the drums getting crushed and breached before retrieval. Since the backfill would transfer the load from the ceiling and walls to the waste drums, stacking the drums in the rooms without backfill would resolve the immediate problem of how to maintain 5 year retrievability. DOE therefore made a decision to defer emplacement of backfill until after 5 years of WIPP waste emplacement operations. Up to 126,000 drums of CH-TRU waste are thus planned to be stacked without backfill in three panels of WIPP during the first five-year period.

For permanent isolation of nuclear waste, emplacement of properly designed backfill around and over the drums is essential. Backfill is the only engineered barrier in the WIPP design and is required by the EPA Standards, the Design Criteria for WIPP, and the Consultation and Cooperation Agreement between DOE and the State of New Mexico. Within the rooms and drifts filled with waste, the backfill would completely occupy the empty space between the drums, the drums and the walls, and the top of the drums and the ceiling. To be most effective, and in order to not leave empty spaces, the backfill should be emplaced after stacking each row of 7-pack drums along the width of a room or drift.

After 5 years, a waste room 300 ft long, 33 ft wide, and 13 ft high would be filled with 6000 drums of CH-TRU waste stacked 3 drums high. The distance between the ceiling and the top of the drums would be barely 2 feet. To attempt to emplace backfill from the end of a 300 ft long room by "pneumatic stowing" may not accomplish the desired goal. Therefore, up to 125,000 drums of CH-TRU waste will have to be removed from the rooms for re-emplacement with backfill. Since the process of removing the nuclear waste drums is elaborate and slow, it is expected to take up to twice as long as emplacement. So for 10 years after the first five-year period, i.e., between the years 1993 and 2003, the WIPP Project will have the task of removing and re-emplacing the CH-TRU drums because the waste will not have been properly emplaced with backfill from the start. Continuous arrival of new waste during this period will make the operations very complicated.

The analyses to judge WIPP's compliance with the EPA Standards 40 CFR 191 are being conducted by a performance assessment team of scientists at the Sandia National Laboratories (SNL). While these analyses will not be completed until 1993, preliminary results show that some reprocessing of waste and redesign of backfill may be required to meet the EPA Standards. To accomplish that, the stored 126,000 drums of CH-TRU waste will not only have to be removed and restacked underground, they may have to be brought to the surface for reprocessing before restacking underground with a designed backfill. The possibility of the repository becoming saturated with brine in a few hundred years after closure has indicated the need for reprocessing the waste and redesigning the backfill. This issue is discussed in more detail in the following sections.

POST-CLOSURE REPOSITORY CONDITIONS: BRINE INFLOW AND GAS GENERATION

Unlike the conceptual designs for a HLW repository, the WIPP design does not include a multi-barrier system concept. The 55-gallon drums will be certified to last for only 20 years and the waste is not fixed in an insoluble matrix. Until 1987, DOE was not willing to commit to include a backfill in the WIPP repository design. The WIPP repository rooms were postulated to close around the waste due to salt creep and entomb the waste drums in 100 to 200 years. Observations in the WIPP excavations since 1983, however, indicate that the salt at the WIPP repository horizon is saturated with brine and the rooms and drifts will begin to fill with brine once the ventilation of the facility ceases to remove moisture (5). In addition, recent electro-magnetic surveys performed directly above the WIPP repository show that brine appears to be present 250 meters below portions of the WIPP repository in the upper part of the Castile Formation (6). Pressurized brine reservoirs in the Castile Formation have been encountered in at least 13 out of more than 60 boreholes drilled to that depth in the area around the WIPP site (7). The one encountered by the borehole WIPP-12 about 2.5 km north of the repository was estimated to contain 17 million barrels of pressurized brine.

The impact of the Salado Formation brine and the Castile Formation pressurized brine reservoirs, on the long-term integrity of the WIPP repository can be determined by analyzing the consequences of breach of the repository. Figure 5 shows some of the postulated breach scenarios based on someone drilling into or through the repository several hundred years after the knowledge of the repository is lost. The EPA Standards (40 CFR 191) do not permit credit to be taken for more than 100 years for maintaining the knowledge about the existence of a nuclear waste repository. Channell (8) and Bard (9) analyzed the consequences of human intrusion involving the Castile Formation brine reservoirs and concluded that the consequences would be acceptable. Much new information is now available, however, and these analyses will have to be updated.

This paper only discusses the consequences of breach of the repository by someone drilling directly into the repository and a slurry of waste and brine coming out to the surface. Consequences of drilling through the repository into the underlying brine reservoir and other scenarios will be analyzed in future publications.

Though anomalous quantities of brine in the WIPP excavations have been noted for several years, the long-term significance of brine inflow has only been appreciated recently. Bredehoeft (5) has shown that the excavations could provide sufficient brine to saturate the closing rooms of the repository in a few hundred years. The danger lies in the possible formation of a radioactive slurry that could be brought to the surface by inadvertent human intrusion. If the waste is in slurry form rather than consolidated into a solid mass by salt creep, enough radioactive material could be brought to the surface through drilling-fluid circulation to exceed the limits set by the EPA Standards, 40 CFR 191. In fact, calculations by SNL (10) show that between 5 and 15 m^3 (30 to 90 barrels) of "slurry" of brine and waste released to the surface will violate the EPA Standards.

More recent SNL calculations (11) discount the brine inflow problem by concluding that inflow will be low enough to be absorbed by backfill without the danger of slurry formation. However, these new calculations are based on non-conservative assumptions of parameters that are not well known. Three important factors in the calculation are formation permeability, formation porosity, and the length of time allowed for brine inflow.

Nowak (11) uses salt permeabilities of 10^{-9} to 10^{-8} darcies to calculate the quantity of brine inflow for 100 years after closure of the repository. These values were chosen because of their consistency with permeabilities calculated from brine inflow observations by Deal and Case (12) in boreholes drilled at the repository level. However, Deal and Case (12) concede that "Evaporation has played a significant role in reducing the measured amounts of brine inflow", a situation that would lead to erroneously low calculated permeabilities. Other SNL investigators have concluded that "for salt, maximum permeability is less than 1 microdarcy" (13) and that values of 10^{-8} to 10^{-6} darcy "are, in fact, representative of the permeabilities estimated for WIPP salt to date" (14). Permeabilities measured in the marker beds and clay seams located within 1.5 to 3 meters of the rooms (Fig. 6) are much higher, greater than 1 darcy in some cases (17). Given the range in observed values and uncertainties in assumptions used to calculate permeability, brine inflow calculations should consider a range in Salado Formation permeability of at least 10^{-9} to 10^{-6} darcies.

Assuming similar permeabilities, the Nowak (11) calculations result in inflow quantities an order of magnitude less than those in Bredehoeft (5) because of the porosity values used. Nowak (11) uses a salt porosity of 0.001, while Bredehoeft (5) uses 0.01. The calculation of permeability from various tests performed in the repository requires the assumption of a porosity value, but the calculations are not always particularly sensitive to the porosity value chosen (15, 16). Calculated Salado porosities range from 0.01 to 0.001 (13, 17). As with the permeabilities, at least this full range of repository porosity values should be used in calculating brine inflow.

Another critical unknown in determining the consequence of brine inflow is the period of time which the calculations consider. Nowak's (11) analysis assumed that "salt creep is expected to close these rooms within 100 years, preventing further accumulations of brine." However, room closure is not the controlling factor; brine flow is caused by the pressure gradient between the in situ brine and the open rooms and will continue as long as that gradient exists. Though the rooms may be effectively "closed" (floor and ceiling touching) within 100 years, the repository will be far from the conditions of undisturbed salt. Brine will continue to flow into the area around the waste until no pressure gradient exists between brine in the formation and brine in the excavated area. A question remains as to how much open pore space is needed to allow the waste to become entrained in a slurry. The brine inflow calculations should, therefore, be carried out past 100 years and in conjunction with repository closure models in order to adequately predict the state of the waste repository rooms.

Gas generation is another factor that may affect repository closure and brine inflow into a waste room. Gas can be generated during waste degradation by four means: 1) radiolysis, 2) thermal decomposition and dewatering, 3) chemical corrosion, and 4) bacterial action. Gas generation was a matter of concern when developing the Waste Acceptance Criteria (18) because of the possibility of fires and explosions during operations and pressurization and mine inflation after closure.

Assuming a gas-generation rate of 5 moles/drum/year, a salt permeability of $5x10^{-7}$ darcy delays creep closure until the gas producing material is exhausted in 400 years (18). In this case, the drifts do not completely close until the gas has diffused into the salt, 800 years after the repository is decommissioned. Calculations using a formation permeability of $5x10^{-7}$ darcy resulted in the mine pressure exceeding lithostatic pressure, "allowing the drift to remain open and even expand slightly" (18). The gas generation rate that will actually occur is very uncertain; 5 moles/drum/year may or may not be conservative.

The retardation of closure by gas generation could allow hundreds of more years of open void space in the repository. Brine inflow will slow and eventually cease if the pressure exceeds the hydraulic pressure of the brine in the adjoining formation. However, the time period of flow to consider could be much longer than the 100 years assumed by Nowak (11) and thus the brine inflow volumes could be greater. With the 10^{-9} to 10^{-8} darcy permeabilities assumed by Nowak (11) and a 5 mole/drum/year gas generation rate, the repository will remain open indefinitely due to gas pressurization. Though brine inflow may cease (and indeed could be reversed) as pressures build above lithostatic, a slurry situation could occur anyway if a drill hole penetrates the repository and drilling fluid entrains the uncompacted waste.

The research in support of the Waste Acceptance Criteria (18) used a value for in situ permeability of 10^{-5} darcy, based on measured in situ permeabilities. In an effort to be conservative, gas generation limits were based on calculations involving mine permeabilities of 10^{-7} darcy. Given the 10^{-9} to 10^{-8} permeabilities assumed by Nowak (11), the WAC gas generation limit of 5 moles/drum/year could lead to mine inflation. The problem of gas buildup is compounded by the presence of brine. The WAC calculations assumed that gas flows into unsaturated pore spaces in the salt. Stormont et al (13) observe that "dissipation of the gas may be retarded or even precluded if the pore space surrounding the storage rooms becomes completely brine-filled."

The discussion so far has not addressed the influence of heat on brine migration. While the heat loading of Ch-TRU waste will be very low, that of RH-TRU will be more. Nevertheless, there will be some effect of heat on brine migration in the rooms. An integrated analysis coupling the effects of room closure, brine inflow, gas generation, and temperature is clearly needed to adequately predict post-closure repository conditions. Additional experimental data may also be required for confidence in the calculations. Reasonable ranges in parameter values should be used to evaluate all possible repository conditions. Any problems revealed by such an analysis could likely be resolved with design modifications, engineered barriers, or by waste processing. Clearly, it would be simpler and result in less radiation exposure at WIPP if the waste were not stored until the necessary analyses and experiments have been conducted and the final waste disposal designs have been determined.

CONSEQUENCE ANALYSIS FOR A WET REPOSITORY

The EPA Standards (40 CFR 191) limit the quantity of radionuclides that are projected to reach the accessible environment in 10,000 years by expected or accidental releases. Only accidental releases with an estimated probability of occurrence greater than 0.001 in 10,000 years need to be considered. Any radionuclides reaching the ground surface due to human intrusion (e.g., an exploratory borehole seeking natural resources) would be considered as reaching the accessible environment even if they were contained in a drilling mud pond.

The EPA Standards suggest that an exploratory drilling frequency as high as 30 boreholes per square kilometer in 10,000 years is appropriate in sedimentary rock formations and do not permit taking credit for institutional controls for more than 100 years. This rate leads to the estimate that about 4.2 boreholes will penetrate a waste storage room at WIPP in 10,000 years. Therefore, drilling into the repository is an expected event. In order to introduce probability into this calculation, it is necessary to assume that the room that is drilled into is in worse condition than the average room and/or that the concentration of radionuclides in the room is somewhat greater than average. The total probability (Pt) can be expressed as:

$$Pt = (Pw)(Pr)\ H \geq 0.1 \text{ or } \geq 0.001$$

where Pw and Pr are the probability distributions for the waste (w) and room (r) and H is the number of hits in a repository room in 10,000 years (4.2). Thus, the product of probabilities is

$$(Pw)(Pr) \geq 2.4\text{x}10^{-2} \text{ or } \geq 2.4\text{x}10^{-4} \quad .$$

The quantity of waste brought to the surface from drilling through the repository is dependent upon the condition of the waste storage room at the time of drilling. If a room is compacted, the quantity of waste brought to the surface would be about equal to that intercepted by the drill bit. If the room is unconsolidated, it is reasonable to believe that all of the contents of a container would be brought to the surface if the drill bit intercepted any part of the container. A waste storage room filled with a brine slurry might have as much 45 m^3 brought to the surface before an unusual occurrence was recognized. Considerably greater quantities could also reach the surface if drillers were careless. In fact, EPA guidance states that 200 m^3 can be presumed to be pumped to the surface and greater quantities can be assumed if it would flow naturally.

At the present time, it is not certain which room conditions will prevail and for what period of time. The key parameters are initial void space, rate of closure of the rooms, and the rate of brine inflow to the rooms prior to complete closure. The expectation that the waste will generate substantial quantities of gas further complicates the prediction of room closure times.

The calculations below assume that 100% of the rooms will remain in a brine slurry condition, i.e., that Pr = 1.0. However, it needs to be kept in mind that a somewhat lower volume of Pr could exist and be used in the calculation since it is the product of (Pw)(Pr) that must be equal to or greater than 2.4×10^{-2} or 2.4×10^{-4}. Therefore, the determination that the average room will not develop a brine slurry condition does not justify the exclusion of the scenario.

The value of Pw could be either $\geq 2.4 \times 10^{-2}$ or $\geq 2.4 \times 10^{-4}$ and still have an overall probability large enough to be considered in the EPA Performance Assessment. There is a considerable variation in the average radionuclide concentration of wastes from the several waste generating sites.

The calculation below uses combinational analysis to estimate the number of TRUPACT's of loads of the more heavily concentrated Savannah River Plant (SRP) and Los Alamos National Laboratory (LANL) waste that could be placed in the affected ara of the repository with a Pw value $\geq 2.4 \times 10^{-2}$. The remainder of the wastes brought to the surface is assumed to be an average concentration from the other generating sites. Average radionuclide concentrations and distributions are taken from the 1987 Integrated Data Base (DOE/RW-0006 Rev. 3).

The affected area in the repository room is assumed to be a right circular cylinder with the height of the room (3.96m) and diameters of 4.25 m and 8.82 m (for room material volumes of 45 m^3 and 200 m^3. The smaller cylinder would intersect 3 rows of stacked 7-packs, 21-27 7-packs, and portions of 7 TRUPACT loads. The larger cylinder would intersect 5 rows, the entire width of the room, 12 full TRUPACT loads and one partial load. The results are shown in Table 1.

Table 1

Quantity of Waste Reaching the Surface
(Curies of Alpha Radiation - Undecayed)

Waste Sources	% Total Waste Volume	Average α Ci/TRUPACT	Number of TRUPACT's		α Curies Reaching Surface	
			$45\ m^3$	$200\ m^3$	$45\ m^3$	$200\ m^3$
SRP	12.6	1308	3.19	4.25	1416	5559
LANL	9.9	515	1.21	1.47	212	756
Other	77.5	42	3.60	6.78	52	288
TOTAL	100.0		8.0	12.3	1680	6603

The EPA Standards permit 100 curies of alpha emitting TRU waste to reach the accessible environment per million curies of TRU waste emplaced if the probability of occurrence is ≥ 0.1. Since 4.8 million curies are estimated to be emplaced at WIPP, the limit to reach the accessible environment is 480 Ci. The above numbers greatly exceed this value before allowing for decay. However, decay is substantial because, with the mix of waste assumed about 87% is ^{238}Pu which has an 87 year half-life. The time taken to decay to 480 Ci is 210 years for 45 m^3 volume and 1240 years for the 200 m^3 volume.

The calculation is very approximate and uses waste inventory data that has considerable uncertainty. Also, the calculation was done to estimate the maximum number of curies that would reach the surface from a scenario in the first few hundred years, not the maximum number that may be present in 5,000 or 10,000 years. Other assumptions could significantly increase the amount of ^{239}Pu and ^{240}Pu that reached the surface. For example, if the affected area in the 200 m^3 scenario included 4-LANL, 4-Hanford, and 4.5-Rocky Flats Plant TRUPACT loads, there would still be 482 Ci present at 10,000 years.

It is concluded that the quantities of radionuclides that could reach the surface from drilling into a brine slurry room are substantial and close enough to the EPA Standard that the probabilities of having brine-slurry conditions need to be determined and more precise calculations need to be performed with the most up-do-date inventory data.

CONCLUSIONS

The Department of Energy has planned to store, without backfill, up to 126,000 drums of contact-handled transuranic waste in the WIPP repository for the first five years of WIPP operations, scheduled to begin in October 1988. Since a properly designed backfill is required by the EPA Standards, the agreement with the State of New Mexico and WIPP project's own design criteria, the 126,000 drums will have to be removed and re-stacked with backfill.

Recent observations of brine inflow from the salt rock into the repository excavations indicate that the repository may become saturated with brine in a few hundred years after closure. Since the CH-TRU waste containers are ordinary 55-gallon drums that will become corroded and breached within a few tens of years, the brine could form a slurry of waste in the repository rooms. Preliminary calculations indicate that this condition may result in violation of the EPA Standards (40 CFR 191.13). Recently published maximum estimates of brine inflow for the first 100 years of the repository do not appear to use conservative hydrologic parameters. There does appear to be a potential problem of long-term isolation of waste at WIPP under the existing design. Engineering solutions to prevent the problem include reprocessing of each drum to reduce the void space and inclusion of cement or chemical grouts in the backfill. Less expensive engineering solutions have not yet been identified, although it would perhaps be possible to include a mechanism for removal of brine from the repository level and provision of some absorbent material at a lower level.

If the 126,000 drums have to be reprocessed, they may have to be brought back to the surface and taken down again for final emplacement with properly designed backfill. It would be simpler and reduce radiation exposure at WIPP to emplace substantial quantities of waste underground only after the decisions about any needed reprocessing of the waste drums and the design of backfill have been finalized.

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POTENTIAL PROBLEMS RESULTING FROM THE PLANS
FOR THE FIRST FIVE YEARS OF THE WIPP PROJECT

<u>List of figures for Chaturvedi, Channell, Chapman Paper</u>

(To be typed below the figures after reduction.)

Fig. 1: Location of the WIPP site.

Fig. 2: Generalized geologic cross-section at the WIPP site.

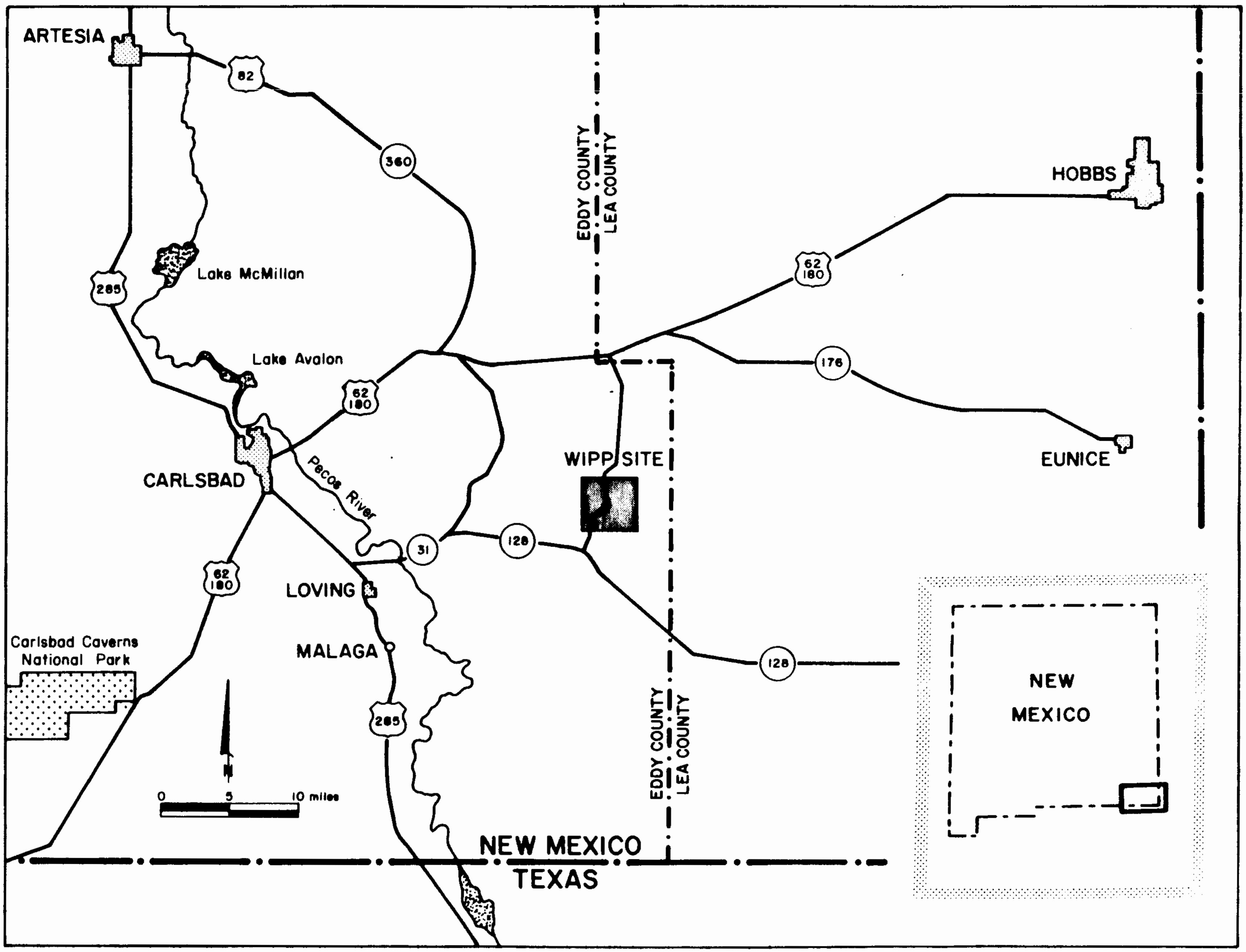
Fig. 3: Underground layout of the WIPP repository and the experimental area.

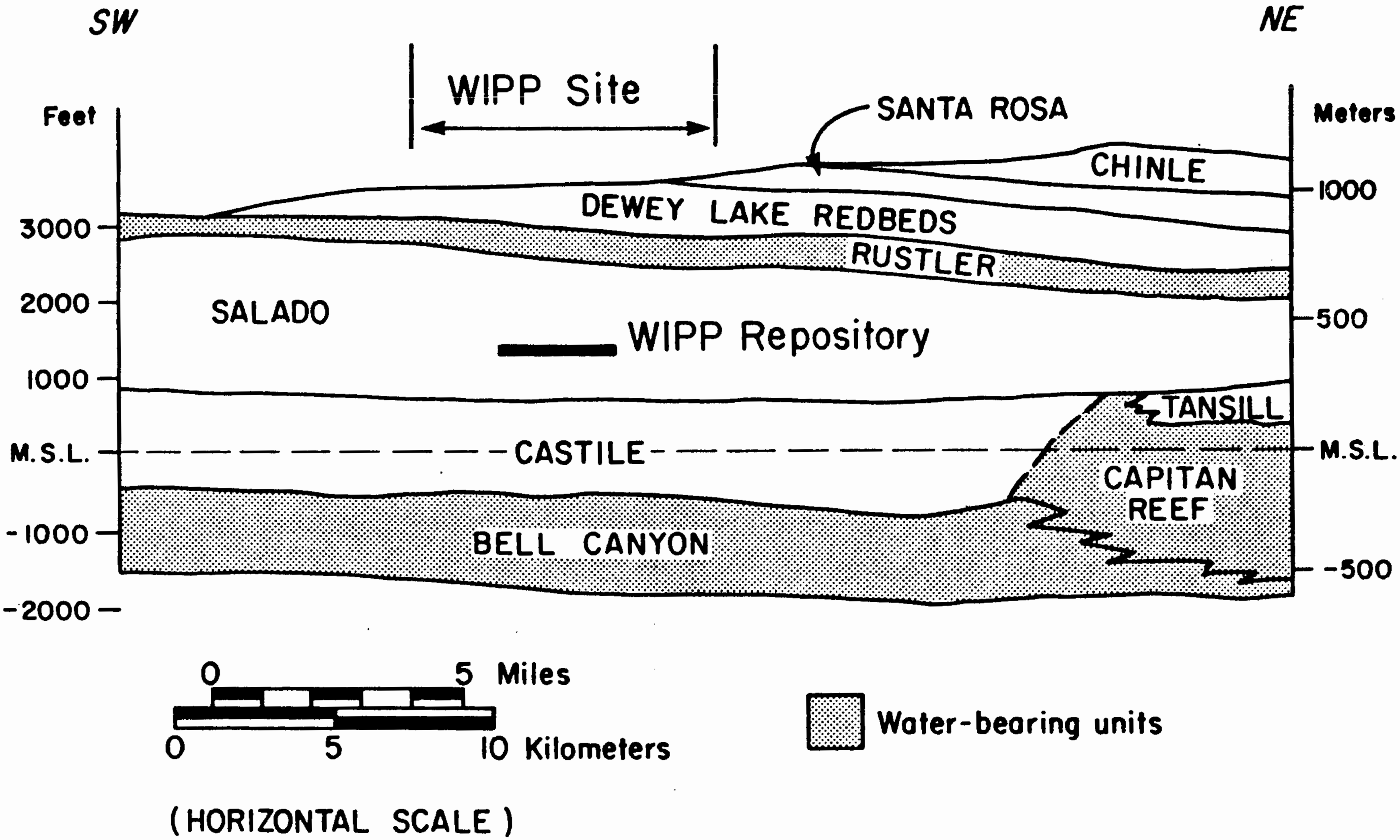
Fig. 4: Roof-to-floor closure rate of the experimental rooms at WIPP.

Fig. 5: Postulated breach mechanisms of the WIPP repository.

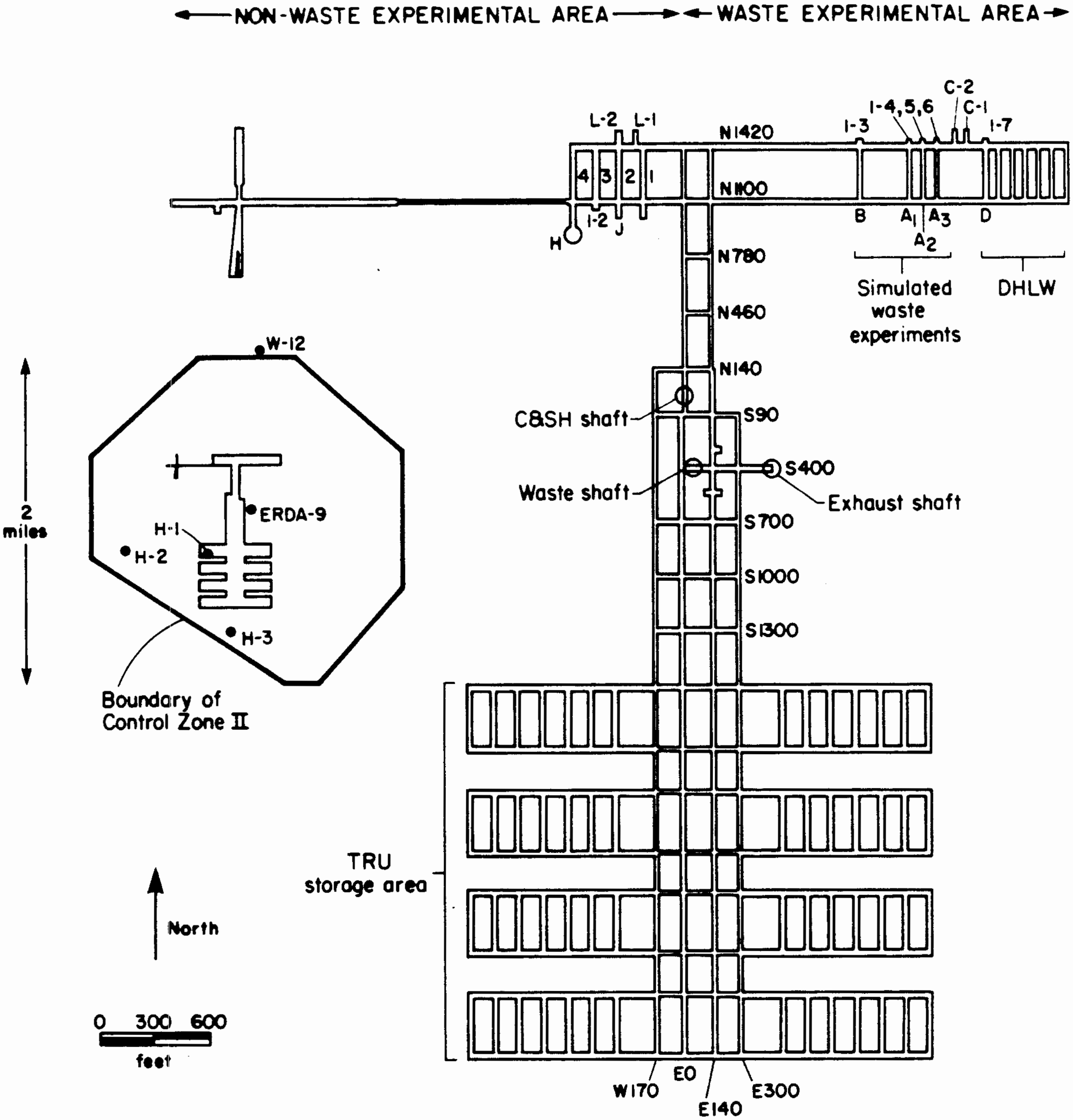
Fig. 6: Clay and anhydrite layers immediately above and below the WIPP repository.

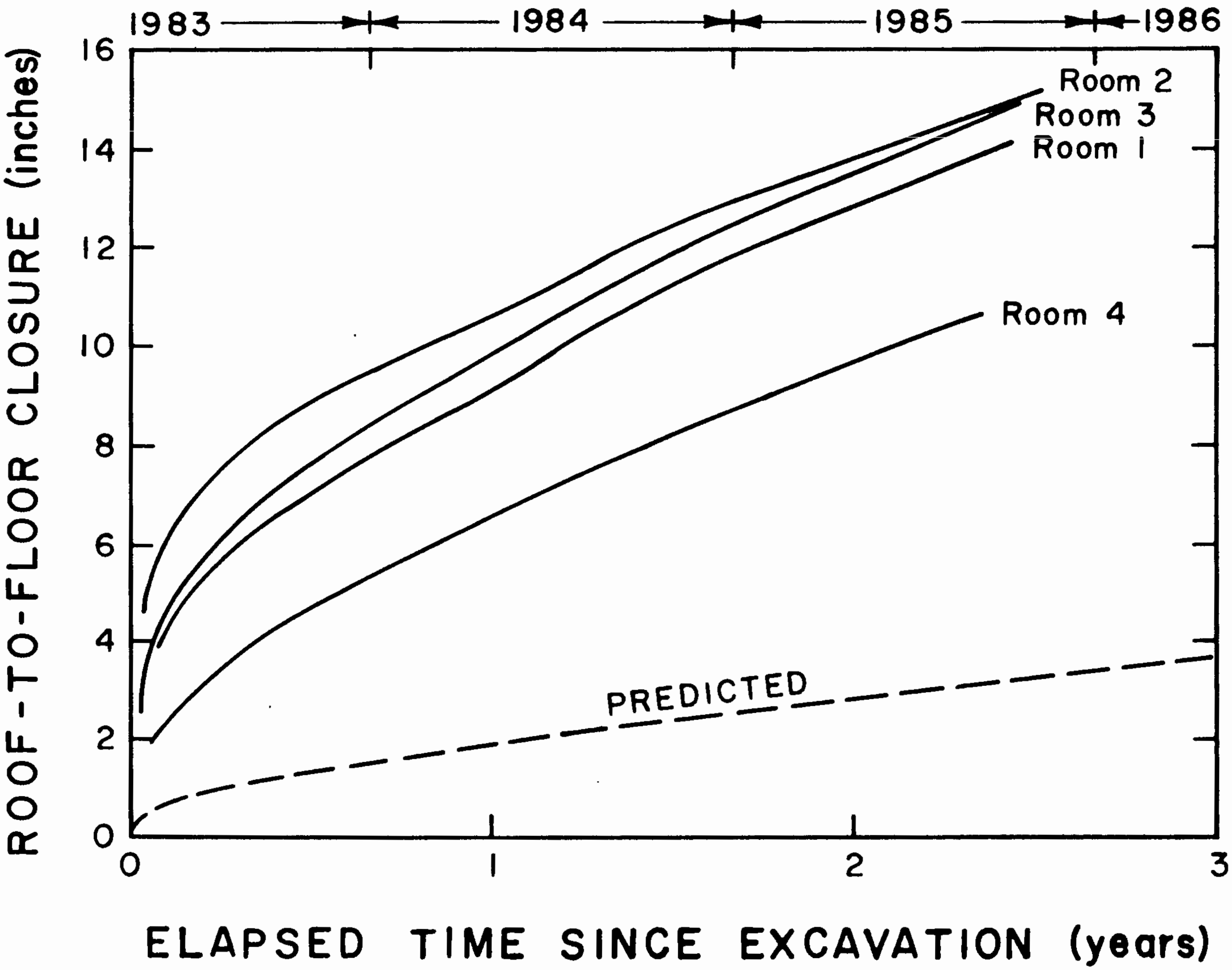
Location of the WIPP Site





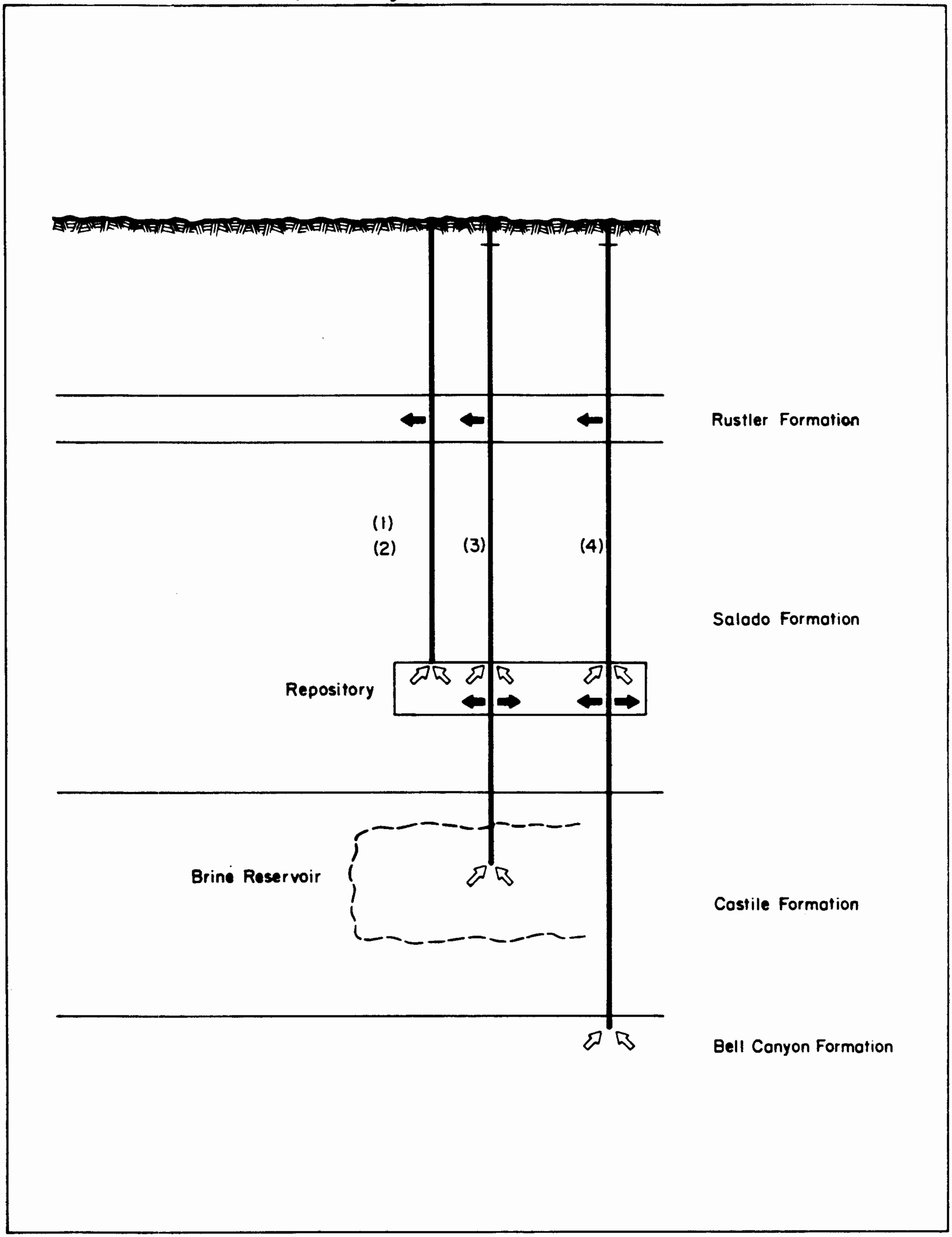
SW
NE
WIPP Site
SANTA ROSA
Feet
Meters
CHINLE
1000
DEWEY LAKE REDBEDS
3000
RUSTLER
2000
SALADO
500
WIPP Repository
1000
TANSILL
M.S.L.
CASTILE
M.S.L.
CAPITAN
REEF
-1000
BELL CANYON
-500
-2000
0
5 Miles
0
5
10 Kilometers
(HORIZONTAL SCALE)
Water-bearing units

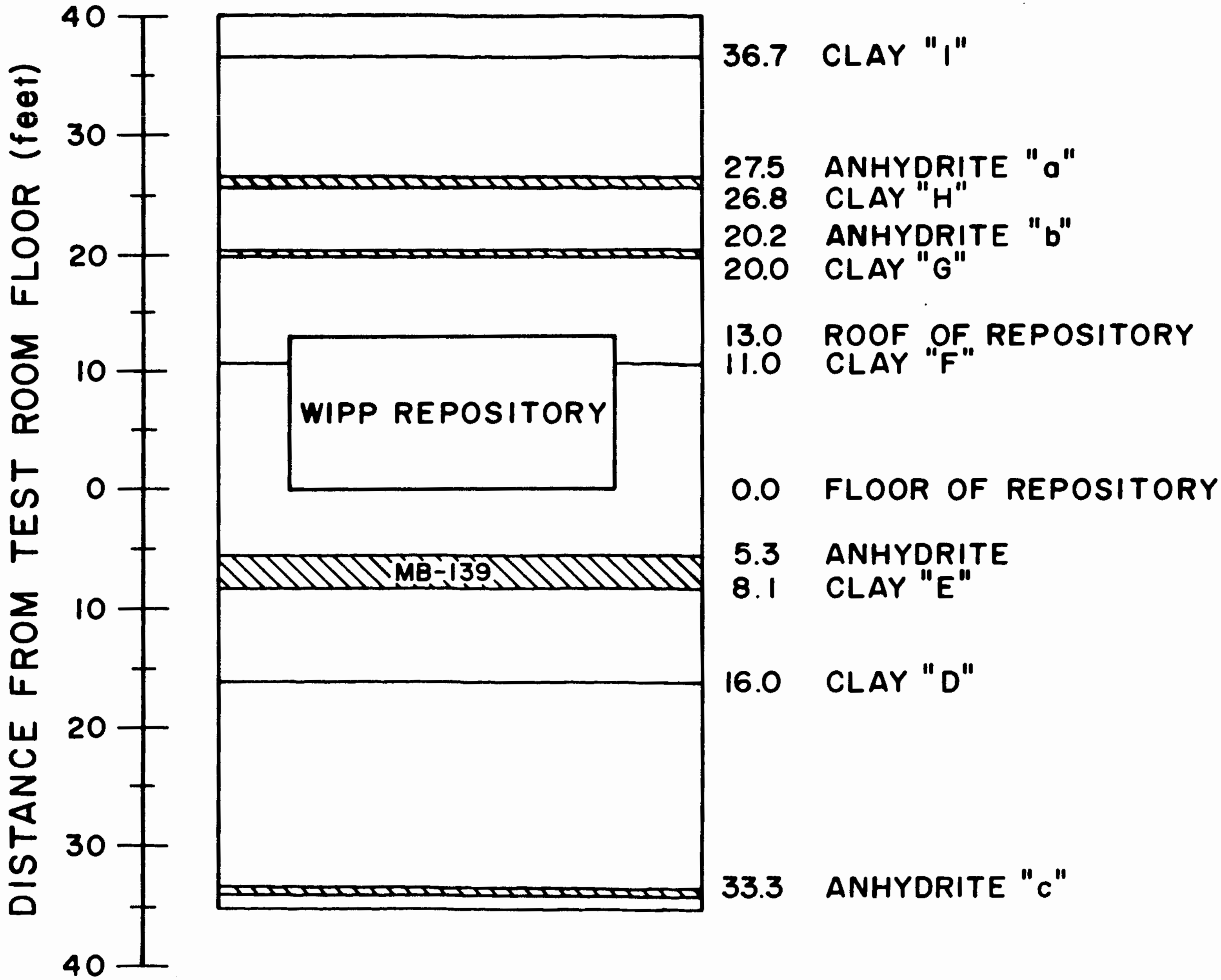

NON-WASTE EXPERIMENTAL AREA
WASTE EXPERIMENTAL AREA
L-2
L-1
N1420
I-3
I-4,5,6
C-2
C-1
I-7
4
3
2
1
N1100
I-2
J
H
B
A1
A3
A2
D
Simulated waste experiments
DHLW
N780
N460
N140
W-12
C&SH shaft
S90
Waste shaft
S400
Exhaust shaft
S700
S1000
S1300
2 miles
ERDA-9
H-1
H-2
H-3
Boundary of Control Zone II
TRU storage area
North
0 300 600
feet
W170
E0
E140
E300



1983
1984
1985
1986
Room 2
Room 3
Room 1
Room 4
PREDICTED
ROOF-TO-FLOOR CLOSURE (inches)
0
2
4
6
8
10
12
14
16
0
1
2
3
ELAPSED TIME SINCE EXCAVATION (years)

Repository Breach Mechanisms




DISTANCE FROM TEST ROOM FLOOR (feet)
40
30
20
10
0
10
20
30
40
WIPP REPOSITORY
MB-139
36.7 CLAY "I"
27.5 ANHYDRITE "a"
26.8 CLAY "H"
20.2 ANHYDRITE "b"
20.0 CLAY "G"
13.0 ROOF OF REPOSITORY
11.0 CLAY "F"
0.0 FLOOR OF REPOSITORY
5.3 ANHYDRITE
8.1 CLAY "E"
16.0 CLAY "D"
33.3 ANHYDRITE "c"