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EVALUATION OF THE DOE PLANS FOR RADIOACTIVE EXPERIMENTS AND OPERATIONAL DEMONSTRATION AT WIPP

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Environmental Evaluation Group
New Mexico

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FOREWORD

The purpose of the Environmental Evaluation Group (EEG) is to conduct an independent technical evaluation of the Waste Isolation Pilot Plant (WIPP) Project to ensure protection of the public health and safety and the environment. The WIPP Project, located in southeastern New Mexico, is being constructed as a repository for permanent disposal of transuranic (TRU) radioactive wastes generated by the nation's defense programs. The EEG was established in 1978 with funds provided by the U. S. Department of Energy (DOE) to the State of New Mexico. Public Law 100-456, the National Defense Authorization Act, Fiscal Year 1989, Section 1433, assigned EEG to the New Mexico Institute of Mining and Technology and provided for continued funding from DOE through Contract DE-AC04-79AL10752.

EEG performs independent technical analyses of the suitability of the proposed site; the design of the repository, its planned operation, and its long-term integrity; suitability and safety of the transportation systems; suitability of the Waste Acceptance Criteria and the generator sites' compliance with them; and related subjects. These analyses include assessments of reports issued by the DOE and its contractors, other federal agencies and organizations, as they relate to the potential health, safety and environmental impacts from WIPP. EEG also performs environmental monitoring for background radioactivity in air, water, and soil, both on-site and in surrounding communities.

Robert H. Neill
Director

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SUMMARY

For the last several years, the U.S. Department of Energy (DOE) has maintained the need for a five-year research and development period for the Waste Isolation Pilot Plant (WIPP). First attempts to define the experiments with transuranic waste (TRU) were made in 1988. Several draft plans have been prepared by DOE during the past 1 $^{1}/_{2}$ years, all of which proposed to measure the rate of gas generation from contact-handled transuranic (CH-TRU) waste drums. The amount of waste identified for the experiments has varied from 0.5% to 15% of the total WIPP inventory. The most recent plans call for approximately 0.5% for gas measurement and 2.5% for Operational Demonstration.

The Environmental Evaluation Group (EEG) does not see a need for shipping any waste to WIPP for operational demonstration before the facility can be demonstrated to meet compliance with the Environmental Protection Agency (EPA) Standards, contained in 40 CFR 191 and currently being revised by EPA following a 1987 court order. No experiments with remote-handled transuranic waste (RH-TRU) have been identified.

Detailed DOE-approved plans for experiments with CH-TRU waste are not yet available. This evaluation is based on the preliminary drafts of bin-scale and room-scale experiments that are not yet approved by DOE. Plans for the laboratory-scale experiments are scheduled to be published in October, 1989. DOE officials and the State's decision-makers have asked for this analysis, which is based on the material available to EEG through September 15, 1989.

DOE's stated justification for the experiments is to generate reliable data on gas generation from the waste, for use in predicting long-term behavior of the repository conditions. DOE's scientists, responsible for assessing the long-term integrity of the repository by assessing compliance with the EPA Standards (40 CFR 191), have stated that there are difficulties in meeting such compliance for the breach scenarios involving future drilling into the repository. Gas generation rates greater than 0.1 mole/drum/year appear to create problems for long-term integrity. The best estimates of gas production rates are 25 to 50 times this rate, viz. 2.5 to 5 moles/drum/year. It does not appear likely that the experiments will yield a rate of gas generation low enough to be acceptable for prediction of satisfactory long-term performance of the repository.

Part of the problem in making a satisfactory assessment of the validity of the proposed experiments is non-availability of the procedures used to reach conclusions of potential non-compliance with the EPA Standards. Also, very high gas pressures predicted in the repository by DOE scientists do not seem to have considered whether several gas generation processes could continue under expected conditions for several hundreds of years. Nevertheless, gas generation appears to create problems within a few tens of years after closure of the repository, and some mitigation measures, engineered modifications of the waste and/or surroundings, may have to be found. This appears to be a more important activity at this time, rather than refinement of the gas generation rates.

Precious time has been lost by not starting the bin-scale tests at one of the DOE waste generator sites, since the problem was identified in 1979 and again surfaced in 1987. The current design of the bin-scale tests should yield information on the contribution of various factors in gas generation. The tests could be expanded in scope to include study of various engineered modifications, such as different kinds of getter materials and different kinds of additional processing of the waste and the drums. EEG believes that this should be done and the bin-scale experiments should begin as soon as possible. The plan for the alcove tests needs more refinement to establish that there is a possibility of obtaining quantitative data in time for performance assessment and that experimental problems (e.g., room sealing) are manageable.

In proceeding with these experiments, it should be kept in mind that the results will most likely not help in showing compliance with the EPA Standards. If properly conceived and redesigned, they may yield useful information for selecting effective engineered modifications to solve the problems that have already been predicted.

1. INTRODUCTION

1.1 Background

The site for the Waste Isolation Pilot Plant (WIPP), 25 miles east of Carlsbad, was chosen in the mid-1970s for permanent disposal of radioactive waste. After twice moving the specific location for the repository and several changes in its mission, the present site was selected in 1982 to provide a suitable place where transuranic nuclear waste, generated from the nation's defense activities, could be safely isolated permanently. The WIPP surface and underground facilities have been designed and built to make it a permanent repository for all the defense transuranic (TRU) waste that is retrievably stored and expected to be generated through the year 2013. The projected maximum volume is 6.2 million cubic feet of contact-handled transuranic (CH-TRU) and 250,000 cubic feet of remote-handled (RH-TRU) waste. There is basically nothing "pilot" about WIPP, except that the U.S. Department of Energy (DOE) plans to emplace up to 8% of the total quantity of waste in an easily retrievable mode during the first five years of the project.

The 1979 authorizing legislation for WIPP (P.L. 96-164) established its mission to be "...a research and development facility to demonstrate the safe disposal of radioactive wastes resulting from the defense activities and programs of the United States..." A great deal of work, at a cost of about $800 million to date, has been conducted since 1974 to assess whether this is a good site for the permanent disposal of transuranic radioactive wastes, to test the waste containers in brine, and to develop backfill, plugs and seals, transportation containers, etc. The effort has required the drilling of 65 boreholes and miles of geophysical exploration surveys, examination of thousands of feet of rock cores, extensive laboratory studies and analysis of data, several tens of man-years of field-work, laborious testing on the surface and underground, and excavation of four shafts and miles of tunnels. The results of most of this work are summarized in two publications, Lappin (1988) and Tyler, et al. (1988), which were prepared at EEG's request (State of New Mexico/DOE, 1984, p. 11).

The U.S. Department of Energy planned to begin shipping waste to WIPP in October, 1988 to initiate experiments with radioactive wastes. Among the reasons that the date was not met was the absence of an acceptable plan for experiments requiring emplacement of waste underground. DOE has now proposed emplacement of waste at WIPP for "experiments and operational demonstration" (U.S. DOE, 1989a). The concept of experimenting with the TRU wastes has been discussed within the WIPP project over a number of years, but the WIPP Project Office (WPO) did not begin to develop these plans until 1988.

1.2 Evolution of Experimental Plans

The first comprehensive report on the WIPP in situ testing plan was published by the Sandia National Laboratory (SNL) in 1982 (Matalucci, et al., 1982). In spite of the title of this report, however, it did not contain any proposal for experiments with transuranic wastes but did contain a proposal for emplacing 1.4 million ft^3 (22.7% of the WIPP capacity of 6.2 million ft^3) of TRU waste as "initial pilot emplacement operations...during the retrieval period" (Matalucci, et al., 1982, p. 98). Several other "Test Plan" reports (Molecke, 1984; Molecke and Wicks, 1986; Molecke, 1986; Molecke and Munson, 1987; and Matalucci, 1987) by the Sandia group in charge of WIPP experiments, published between 1983 and 1987, also do not contain any proposals for emplacement of TRU wastes at WIPP for experiments. They only propose or describe experiments to study the effect of brine and humidity on empty 55-gallon drums; selection of backfill; plugging and sealing of the boreholes, shafts, and tunnels; rate of closure of the rooms with or without heat; etc. On January 7, 1987, Sandia National Laboratories transmitted "Preliminary Details of the WIPP Radioactive Tests (WRT)" to DOE (Weart, 1987). This memo of record described only the high-level waste experiments and did not describe any experiments with TRU wastes.

Since DOE had planned to start shipping waste to WIPP in October, 1988, EEG requested information on experiments several times verbally in 1987 and formally requested this information in a December 31, 1987 letter (Appendix A). In October 1987, there was as yet no written justification for shipping the waste to WIPP, but DOE announced plans to ship up to 126,000 drums (15% of the total WIPP capacity) for "Research and Development" (Wade, 1987). EEG analyzed the implications of this statement and concluded that DOE should not ship substantial quantities of waste to WIPP until "after the decisions about any needed reprocessing of the waste drums and the design of backfill had been finalized" (Chaturvedi, Channell, and Chapman, 1988, Appendix B).

A draft of the first report that outlined the DOE plans for experiments with TRU wastes at WIPP, entitled "Panel One Monitoring Plan for the Waste Isolation Pilot Plant" (U.S. DOE, 1988a), was received by EEG in March, 1988. It identified three types of information which would be obtained from monitoring the behavior of the storage rooms: 1) structural response, 2) gas generation and/or consumption, and 3) brine accumulation. The report proposed filling four of the 56 WIPP "rooms" with CH-TRU waste to monitor gas generation. The specific quantity of waste was not identified, but at approximately 6,000 drums per room, it would be about 24,000 drums (2.8% of the total volume). The monitoring plan was not designed to observe processes that might occur subsequent to rupturing of containers and this severely limited the validity and usefulness of the proposed experiments for predicting the conditions in the repository beyond a few tens of years. There were several other deficiencies and omissions in the plan. EEG sought clarifications on several points through a letter to DOE dated May 11, 1988 (Appendix C). We did not receive a reply to this letter and the report was never published.

The second report (U.S. DOE, 1988b) that contained an outline of experiments requiring emplacement of waste at WIPP was given to EEG for review on June 16, 1988. This 260-page draft report was a collection of studies proposed by Sandia and Westinghouse scientists and engineers to aid in consequence analyses involving breach scenarios, backfill selections, rock mechanics, durability of 55-gallon drums, plugging and sealing of excavations, and hydrologic testing. Hidden in the report were three pages (Section 6.2) on "Gas Monitoring" that sought to provide the justification for shipping 25,000 drums of CH-TRU waste to WIPP "to allow a quantification of the uncertainty in predicting the amount of gas generated/consumed in any one of the rooms at WIPP" (U.S. DOE, 1988b, p. 6-3).

In a July 13, 1988, letter (Appendix D), EEG concluded that the DOE's Five-Year Test Plan lacked coherence and internal consistency. The plan required data by the end of 1990 to perform calculations for long-term safety assessment, but, even under the most favorable circumstances, that would have been unachievable. Also, while the plan placed much emphasis on the need to study the effect of "synergism," or interaction between gases, brine, rock, and metal, the proposed efforts to retain the multilevel isolation of the waste would not have allowed such interactions to take place. The tests would be conducted without backfill (to maintain easy retrievability), without allowing brine to accumulate around the drums (to prevent corrosion of the drums), and without allowing gas pressures to build up in the rooms (to avoid hazards to workers). This would have so constrained the experiment that the data would not have represented the actual conditions expected in the repository over a period of time. Finally, we again expressed our concern about the plan to emplace a large quantity of waste without backfill and without a reprocessing decision.

We did not receive a reply to our July 13, 1988, letter on the Five-Year Test Plan, but DOE officials told us verbally that a new plan was being prepared and would be released later in 1988. In September 1988, DOE announced that shipment of waste to WIPP would be delayed until 1989. As late as January 1989, EEG was requesting justification for preparations to ship waste to WIPP, but none was available (see Appendix E).

A new plan (U.S. DOE, 1989a) was received by EEG on April 26, 1989. This time the title was, "Draft Plan for the Waste Isolation Pilot Plant Test Phase: Performance Assessment and Operations Demonstration." As before, this 300 page document contained only six pages (p. 2-106 to p. 2-112) of an outline of experiments with radioactive waste plus a 24-page Appendix entitled, "Tests with CH-TRU and Simulated Wastes," that contained some additional description of the tests. The document did not, however, contain the detailed plans that would provide a basis for a technical review of the merit of temporary emplacement of a large quantity of waste. These were to be provided sometime in "mid-FY89"

(U.S. DOE, 1989a, p. 2-109 and 2-112).

The document (U.S. DOE, 1989a) proposed shipping 8% of the WIPP design capacity (approximately 500,000 ft^3 or 68,000 drums) for "testing and operational demonstrations" during the Five-Year Test Phase. The plan was, however, obsolete at the time of its issue. A "Notice to Reader" attached to the plan, changed the limit to 3% of waste for the first three year period, without providing any technical justification. DOE still reserved the right to self-determine whether to emplace up to 8% of the total inventory during the five year period.

Because of inadequate details in the document (U.S. DOE, 1989a), EEG sought clarification on a number of points through a letter dated May 15, 1989 (Appendix F). Replies to questions raised in this letter were received by EEG on July 11, 1989 (Appendix G). These responses state that out of the three proposed scales (lab-scale, bin-scale, and room-scale) of experiments, the test plan for the lab-scale experiments will not be available until October 1989 (response to question 14, Appendix F) and the test plans for the other two were provided to EEG as preliminary drafts, unapproved by DOE, which are "presently undergoing internal review and may be modified by on-going reviews" (response to question 13, Appendix F). EEG participated in a peer review of the draft plans on August 23 and 24, 1989.

While a thorough review of DOE plans should ideally await receipt of detailed, DOE-approved plans, there is so much interest in these plans that an evaluation is being provided based on the information available to us through September 15, 1989.

2. OPERATIONAL DEMONSTRATION

EEG's interim evaluation of U.S. DOE (1989a) was issued on July 9, 1989, in response to a request from Senator Pete Domenici. This evaluation (Appendix H) included EEG's position on the operational demonstration part of the plan and it is repeated below.

> DOE proposed to ship 18,300 drums for operational demonstration during a three-year period and would reserve the option to emplace as many as 63,500 drums for operational demonstration (68,000 total drum-equivalents minus 4,500 drum-equivalents for scientific experimentation) before meeting the Standards. We do not believe that waste should be brought to WIPP for this purpose prior to proving that the facility can meet the Standards for safe disposal for the following reasons:
>
> 1. There is little technical knowledge or experience to be gained in conducting waste handling activities at WIPP before completing a number of required actions. Waste certification is occurring at the generating sites, as is packaging and waste handling. DOE has transported more than 100,000 CH-TRU waste drums from the generating sites to INEL since 1970 and is still transporting drums today.
>
> 2. The emplacement of 18,300 drums before making a decision on the need to process wastes (e.g., cementation, crushing, incineration,

etc.) could result in needless transportation and operations related occupational radiation exposure. If treatment is required, a facility would have to be built for this purpose at WIPP, or waste would have to be transported back to Rocky Flats or elsewhere for processing.

3. Until DOE commits to the actual waste emplacement conditions including backfill, getters, or other engineering modifications, waste emplacement will not represent actual conditions. And those commitments will be heavily based on the results of the performance assessment.

4. Operational demonstration is unrelated to the demonstration of compliance with the disposal requirements of the EPA Standards.

5. If the scientific experiments with 4,500 drums are conducted, it will require 107 truck shipments. Unloading more than 300 TRUPACTs and moving the material through the system will provide considerable operational experience.

6. It is important to demonstrate an ability to emplace increasing amounts of waste safely, but we see no purpose to doing it twice, now and when the disposal phase begins.

7. DOE has not identified any need to conduct operational demonstrations at the HLW facility in Nevada and has no plans to do so prior to

demonstrating compliance with the EPA and NRC Standards for disposal. Experiments and operational demonstration with HLW at the Climax Mine in Nevada involved a dozen shipments, which is insignificant compared to the 1,500 planned shipments to WIPP for operational demonstration.

3. IMPACT OF GAS PRODUCTION ON PERFORMANCE ASSESSMENT

3.1 Performance Assessment

"Performance Assessment" in this report refers to the assessment of compliance of a radioactive waste repository with the Environmental Protection Agency (EPA) "Standards for the Management and Disposal of Spent Nuclear Fuel, High Level and Transuranic Radioactive Wastes" contained in the Code of Federal Regulations 40 CFR Part 191 (U.S. EPA, 1985). WIPP is required to meet these Standards as will the High Level Waste (HLW) repository for commercial and defense HLW, currently being planned for the Yucca Mountain site in Nevada. Subpart A of the Standards specifies maximum allowable releases for management and storage of radioactive waste and applies to facilities designed for temporary retention of the waste. Subpart B of the Standards is designed to assure long-term integrity of a geologic repository for nuclear waste. These were vacated by the First Circuit Court of Boston in June 1987, and are expected to be reissued by EPA in draft in 1989. DOE and New Mexico formally agreed in 1987 to continue to evaluate WIPP against the 1985 Standards, until the new ones are promulgated.

> According to U.S. EPA (1985), 40 CFR 191.12(q): "Performance assessment" means an analysis that:(1) Identifies the processes and events that might affect the disposal system; (2) examines the effects of these processes and events on the performance of the disposal system; and (3) estimates the cumulative releases of radionuclides, considering the associated uncertainties, caused by all significant processes and events. These estimates shall be incorporated into an overall probability distribution of cumulative release to

the extent practicable."

Compliance with the EPA Standards will thus be demonstrated on the basis of probabilistic risk assessment and does not require emplacement of waste in a repository. In fact, DOE plans to complete such compliance at the Yucca Mountain, Nevada, high-level waste (HLW) repository, based on the geologic/hydrologic information obtained during site characterization. The Nuclear Regulatory Commission (NRC) requires DOE to demonstrate compliance with the Standards (U.S. EPA, 1985) before granting a license to begin construction of the HLW repository.

3.2 The Gas Problem

DOE's Test Phase Plan document (U.S. DOE, 1989a) describes the gas generation tests to be "in support of compliance with the EPA Standard, 40 CFR 191, Subpart B" (p. ES-4). The WIPP Project Manager's Monthly Report for June 1989 (U.S. DOE, 1989b, p. 9) states, "All of the tests are designed to determine if WIPP can comply with EPA Standards that establish limits on the amount of radioactive materials allowed into the environment for a period of 10,000 years." These statements and several others made publicly by DOE officials maintain that the gas generation measurements in the repository are vital for assessing compliance with the EPA Standards. Since the only purpose of the proposed in situ experiments with waste is to measure the rate of production of gas from TRU waste, an evaluation of this position requires an examination of the potential impact of additional gas-generation measurements on predictions of long-term isolation of the waste from the environment.

3.3 Gas Generation Rates and Quantities

Molecke (1979) performed a comprehensive review of all applicable gas generation data and experimentally investigated the mechanisms for gas generation, such as radiolysis, bacterial action, and chemical corrosion, as well as thermal decomposition and dewatering. WIPP TRU waste materials expected to produce gases include cellulosics (paper, cotton, cloth, wood, etc.), plastics (polyethylene, polyvinyl chloride), rubbers, concrete-TRU ash, process sludges, asphalt and corrosion of mild-steel drums. The major gases expected to be produced from TRU waste degradation are hydrogen (from radiolysis and from corrosion in an anaerobic, wet environment), carbon dioxide and carbon monoxide (from radiolysis, bacterial degradation, and thermal degradation of cellulosics), methane (from bacterial degradation in an anaerobic environment), nitrogen (from degradation of nitrites, sludges, etc.), and water vapor (release of sorbed water from sludges, moist cellulosics, etc.). The air that will be trapped in the repository will provide oxygen and nitrogen. Oxygen will most likely be used up in the production of carbon dioxide by microbial activity and in the oxidation of metals. Nitrogen will remain and some additional small quantities of N_2 will be contributed by gases geologically trapped in the Salado Formation.

Molecke (1979, Table 14, p. 52) presented the gas generation rates in moles/year/drum for each of the mechanisms. This table is reproduced here as Table 1. The data for each mechanism and each matrix are presented as "lower limit-(most probable range)-upper limit." There is one significant change, however, in the understanding of long-term repository conditons since 1979. Molecke (1979, p. 45) estimated that under humid, anoxic conditions, corrosion of a CH-TRU drum would produce a maximum of 2 moles/year of hydrogen with a total of 672 moles for complete corrosion of a drum. But he assumed dry conditions for the WIPP repository under which the mild steel would be simply oxidized thereby consuming oxygen, but would not produce hydrogen. He concluded, "Under expected repository

TABLE 1

COMPARATIVE GAS GENERATION RATES***

(***Table 14 of Molecke, 1979b, p. 52)

Mechanism	Matrix	Gas Limits (moles/year/drum)*
BACTERIAL	Composite, Aerobic	0-(0.9-5.5)-12**
	Composite, Anaerobic	0-(1.2-4.2)-32
	Plywood Box,* Aerobic	0-(0.44-2.2)-3.0
	(Plywood Box, Aerobic, 3.2 m^3)	0-(2.8-14)-19
	(Plywood Box, Anaerobic, 3.2 m^3)	0-(6.8-23)-26
	Asphalt, Aerobic	0-(0.1-2.6)-8.4
	Asphalt, Anaerobic	0-(0-1.9)-4.8
THERMAL	Composite (40°C)	0-(0.02-0.2)-0.4
	Paper (70°C)	0.5-(1.3)-2
RADIOLYSIS	Cellulosics	0.002-(0.005-0.011)-0.012
	Polyethylene	0.003-(0.007)-0.008
	PVC	0.01-(0.03-0.042)-0.08
	Composite	0.002-(0.005)-0.006
	Asphalt (7.7 Ci)	0.1-(0.15-0.76)-01.0
	Concrete-TRU Ash (poured, 15 Ci)	0.03-(0.045-0.93)-1.0
	Concrete-TRU Ash (heated, 15 Ci)	0.0002-(0.0005-0.035)-0.05
CORROSION	Mild Steel	0-(0)-2.0
ALPHA DECAY	He Generation	0.00002
OVERALL AVERAGE (Volume Basis)	Existing INEL TRU Wastes	0.0005-(0.3-1.4)-2.8 per drum
	or	0.003-(1.5-6.8)-13.5 per m3
	or	0.0001-(0.042-0.19)-0.38 per ft3

* drum volume = 0.21 m^3

** lower limit-(most probable range)-upper limits; with estimated uncertainties.

environmental conditions, the corrosion of steel is not expected to yield significant quantities of gas." (p. 51). The "overall average" of 0.3 to 1.4 moles/drum/year, computed by Molecke (1979) was therefore significantly lower than what it would be with the present understanding of the waste and the gas-producing mechanisms, because it incorporates very low rates for radiolysis and zero for corrosion. The arithmetic mean of 0.3 and 1.4 is 0.85 moles/drum/year, described as the "best estimate" of the microbial gas production rate by Lappin, et al. (1989, p.4-6).

Lappin, et al. (1989, p. 4-8) have called Molecke's calculation of 2 moles/drum/year of H_2 production for 336 years due to corrosion of the drums as the "highest rate" and have a "lowest estimate" of 0.262 moles/drum/year, based on a corrosion period of 2,000 years and the production of 524 moles of H_2 for complete corrosion of a drum (Brush and Anderson, 1988). The 2,000-year period is taken from extrapolation of a laboratory study of the corrosion of a different kind of mild steel (A216 Grade WCA, and not the SAE 1018 steel used for WIPP CH-TRU Waste) by Haberman and Frydrych (1988). This extrapolation of the test data to a lower temperature and lower Mg^{2+} concentration of Salado brines indicated a range of 500 to 2,000 years that will be required for complete anoxic corrosion of the drums. Lappin et al. (1989, p. 4-8) have chosen the higher value of this very wide range of calculated time period and therefore 0.262 moles/drum/year is an unrealistically low value. Nevertheless, they have assumed the arithmetic mean of 2 moles/drum/year (Molecke, 1979 - highest rate) and 0.262 moles/drum/year (lowest estimate), that is, 1.13 moles/drum/year, as the "best estimate" of the H_2-production rate due to corrosion. For the best estimate of total production rate, they assumed 598 moles/drum (the mean of 672 moles estimated by Molecke, 1979, and 524 moles estimated by Brush and Anderson, 1988). These mean values lead to an estimate of anoxic drum corrosion of 1.13 moles of H_2/drum/year for 529 (598 ÷ 1.13) years. Lappin et al. (1989, p. 4-10) have proposed to increase this estimate by 50% to 1.7 moles/drum/year to account for additional corrosion of metal boxes and metallic constituents of the waste. According to them, this makes the "best estimate" of total gas-production rate to be 2.55 moles/drum/year (0.85 from microbial activity and 1.70 from corrosion).

A more straightforward approach to estimate the quantity of gas produced by microbial processes would be to simply take the arithmetic mean of the numbers for bacterial decomposition of composite wastes. From Table 1, this range is 0.9 to 5.5 moles/drum/year for aerobic processes and 1.2 to 4.2 moles/drum/year for anaerobic. The arithmetic mean of the highest and lowest values, 0.9 and 5.5, is 3.2 moles/drum/year and that should be considered a reasonable estimate of gas production due to bacterial processes. The Lappin et al. (1989) estimate of 1.7 moles/drum/year for corrosion-produced gas, while not conservative, may be accepted in the absence of more reliable data. This gives a number of 4.9 (3.2 + 1.7) moles/drum/year as the best estimate of the quantity of gases to be produced. If gas production by radiolysis is added, the number would be even higher. EEG does not believe that gas generation by radiolysis is negligible (EEG, 1989, p. 55). For a G factor of 0.6 to 8.4 used in TRUPACT-SARP (Nuclear Packaging, Inc., 1989) radiolysis would produce 0.38 to 5.38 moles/drum/year of gas (J.K. Channell, personal communication).

Following another approach, Sandia National Laboratories (1979) estimated 5 moles/drum/year as the rate of gas to be produced. A 210-liter (55 gallon) drum containing 60 kg of organics would produce 5,600 moles of gas, if complete conversion took place. Since laboratory data indicated that the conversion would not be complete, an arbitrary estimate of 2,000 moles of gas/drum was made. Using the assumption that the gas generation period is 400 years, a rate of 5 moles/drum/year was projected. This estimate did not include gas generation by corrosion of drums.

It is clear from the discussion above and the very wide ranges of gas generation for each mechanism (see Table 1), that there is much uncertainty in the estimates for the rates and quantities of gas production from TRU waste. Because of the large numbers of contributing factors involved, it may never be possible to significantly narrow this range. However, the data suggest the best estimate of the rate of gas production, without counting the contribution by radiolysis, to be 5 moles/drum/year and not 2.55 moles/drum per year as estimated by Lappin et al. (1989). Similaraly, reported numbers of total gas production per drum, 2,000 moles (Molecke, 1979), or 1,500 moles (Lappin et al., 1989), have no sound basis either. One can only say that it would be less than 5,600 moles.

The only other effort to experimentally measure the rate of gas production from TRU wastes is reported by Clements and Kudera (1985). They measured head-space gases from drums of TRU waste from Rocky Flats Plant (RFP) stored at Idaho National Engineering Laboratory (INEL). While the results of these measurements are very useful for estimating short-term quantities, such as during transportation of these wastes and during operations at WIPP, they are not of much use for predictions of repository conditions after plugs and seals are in place. The measurements were made during near-surface storage at INEL, under low relative-humidity, that prevented significant microbial degradation as well as corrosion.

Since these two processes are expected to generate most of the gas, the experiment did not simulate the conditions in the repository beyond the first few years.

3.4 Gas Production and Breach Scenarios

The potential for damage to the integrity of the repository caused by the gases produced by degeneration of organic materials and corrosion of drums and metals in TRU wastes was recognized very clearly by WIPP scientists as early as 1979. The following quotes from Molecke (1979a) describe the problem most succinctly.

> "Long term concerns are the driving force behind the majority of the WIPP-specific gas generation studies... In the Long term, generated gases are no longer removed by ventilation and concentration and potential pressurization could result - particularly if rates of gas dissipation (via formation permeability) are very low... If the pressure buildup is sufficient, the overburden rocksalt-evaporite sequence may be fractured or a shaft seal may fail. This could lead to a release of potentially contaminated gases (aerosol or vapor entrained) to the surrounding geosphere, or provide a pathway for water intrusion into the repository." (Molecke, 1979a, pp. 3 and 4)

For long-term integrity of the repository, the concern is that the pressures in the repository should not be allowed to exceed the rock pressures (lithostatic pressures) at that depth. The lithostatic pressure at 2,150 feet is about 2,150 psi ($\approx$ 150 atmos or $\approx$ 15 MPa). If the gas pressures in the repository exceed the lithostatic pressure, it may start opening existing fractures until sufficient void space is found to dissipate the excess pressure. The repository will be tightly sealed and there will only be a limited space in the Marker Bed 139 underlying the repository level and in the disturbed rock zone surrounding the excavation. Pressures substantially higher than lithostatic may therefore extend the existing fractures or create new ones to the shafts and up to the Rustler water-bearing zones or even to the surface. The borehole ERDA-9, situated 800 feet from Panel 1 and only 100 feet from E-300 drift, could provide a conduit to the underlying Castile Formation which may contain a pressurized brine reservoir. Breach scenarios involving human intrusion into the repository become more serious if the repository is pressurized, for two reasons: 1) the pressurization prevents the room from closing and allows greater communication between waste containers, drilling mud, and brine cirulation, and 2) the pressure provides a driving force to move brine to the surface.

Lappin et al. (1989) have calculated the accumulation of gas pressures in the repository based on an estimate of 2.5 mole/drum/year of gas production (reproduced here as Table 2). As much as 170 MPa pressure from hydrogen generation from corrosion and 70 MPa pressure from microbial degradation of organic matter will be generated in the repository storage area in about 600 years. Because of limitations of the computational model, the total pressure cannot be accurately predicted but will be more than the sum of the two (170 + 70) or 240 MPa. From the observed rate of room-closure and the expected loading of the repository with waste and backfill, it is projected that the void volume of the repository will be reduced from the initial 280,000 m^3 to a final 13,000 m^3 in 60 years starting from the time the storage area is sealed off. Whether this compaction is completed in 60 years or takes a few tens of years more to reach final compaction, further reduction in void space is not expected. The gas pressures are expected to reach the 15 MPa lithostatic

TABLE 2

(Lappin et al., 1989, Table 4-8, p. 4-81)

Gas Storage Volumes and Calculated Pressures in Storage Area from Maximum Gas Potentials, (Assuming that Salt Does Not Creep Open After Initially closing and Has Zero Permeability).

	Void Space	Final Void Volume x 10^4 m^3	Pressure Total MPa	Pressure Microbial MPa	Pressure H_2 MPa
1.	Excavated Storage (G) (final)	1.3	**	70.0	170.0
2.	Total repository excavation (excluding Shaft) (H)	1.8	**	52.0	98.0
3.	MB 139 and clay seam above excavations (G)	1.2	**	270.0	200.0
4.	MB 139 under, clay seam above plus excavated storage (G)	2.5	190.0	24.0	58.0
5.	MB 139 under, and clay seam above total excavated repository area (H)	1.7	**	59.0	105.0
6.	MB 139 under, clay seam above plus total repository excavation (H) (excluding shaft)	3.4	84.0	16.0	38.0
7.	DRZ in excavated storage area	8.0	25.0	8.1	15.0
8.	DRZ in storage area plus final excavated storage (G)	9.3	21.0	7.2	12.0
9.	DRZ, MB 139, clay seam, plus excavated storage (G)	10.5	18.0	6.5	11.0
10.	Excavated storage (G) (initial, empty)	43.0	4.4	1.8	2.5
11.	Excavated storage (G) (initial, filled)	28.0	6.7	2.7	4.0

** Beyond applicable range of Redlich-Kwong equation of state, as a a result of excessive pressures.

pressure in 60 years and will increase to twice the lithostatic pressure (30 MPa) in 120 years, unless additional void space is created by fracturing or re-expansion of the repository (Lappin _et al_., 1989, Figure 4-13, p. 4-83). Preliminary calculations by Sandia National Laboratories scientists indicate that a gas production rate of 0.1 mole/drum/year generates pressures equal to lithostatic in the repository (Lappin, personal communication, and presentation to the NAS WIPP Panel, June 7, 1989). In short, expected rates and amounts of gas generation in the WIPP repository create difficulties in maintaining long-term isolation of the waste and the rate has to be a factor of 25 to 50 less than the current best estimate, for the potential problem to disappear for the undisturbed scenarios. The problem will still exist for the human-intrusion scenarios.

3.5 Effect of Formation Permeability on Gas Pressurization

Formation permeability has an effect on the gas production rates. Sandia National Laboratories (1979) concluded that a gas generation rate of 5 moles/drum/year and a salt permeability of 5×10^{-8} darcy will exceed the lithostatic pressure in 200 years. However, they optimistically assumed that it would simply delay creep closure until the gas producing material is exhausted in 400 years, after which the pressure would decrease to below the lithostatic in 800 years. Gas permeabilities lower than 5×10^{-8} darcy were measured on ERDA-9 salt rock core samples in 1978 (Powers, _et al_., 1978, p. 9-7). The Sandia National Laboratories (1979) calculations indicated that at a formation permeability of less than 1×10^{-7} darcy, gas pressurization in the repository above the lithostatic pressure would result. If the permeability was assumed to be higher than 1×10^{-7} darcy, maximum pressures would remain below the lithostatic. The National Academy of Sciences WIPP Panel evaluated the question of gas pressurization in 1984 and concluded that "a gas generation rate of 5 mole/year per drum is acceptable." This conclusion was based on the assumption that the formation permeability would be higher than 1 x 10^{-7} darcy. The Panel accepted 1 x 10^{-5} darcy to be the more likely permeability, as measured in some Salado boreholes, and stated, "The higher permeability figures from the field are in fact likely to be more realistic because the bedding-plane seams of clay and anhydride are likely to be major contributors to in-situ permeability" (NRC/NAS, 1984, p. 35).

Permeability measurements on rock-cores were reported by Cooley, Butters and Jones (1978), Sutherland and Cave (1979), Cooley and Butters (1979) and Sullivan (1983). Based on the experiments performed by these investigators, Tyler et al (1988, p. 144) concluded, "the laboratory measurements suggest that the permeability of the undisturbed WIPP salt is less than 0.05 microdarcies", i.e. less than 5 x 10^{-8} darcy.

In situ permeability of the Salado Formation was measured in the borehole AEC-7 in 1979 and the results were published by Peterson et al (1981). These measurements yielded a range of values in the microdarcy range or lower, but were not considered reliable because of short test durations and the assumption of Salado salt being unsaturated.

After excavation of the WIPP underground, in situ permeability measurements on the repository horizon were made between 1984 and 1986. These results were published by Peterson et al. (1985) and Peterson et al. (1987). These measurements used nitrogen gas as the medium and were conducted in horizontal, vertical and angled boreholes drilled from the WIPP drifts. The results from shallow depths (within 1 meter of the excavation into the rock) showed a range of several orders of magnitude from 3 x 10^{-7} darcy and higher. Beyond one meter range, more consistent k values, in the 10^{-8} to 10^{-9} darcy range, were interpreted. This was to be expected because of the effect of disturbed rock zone around the excavations.

Brine flow tests in two boreholes in the WIPP repository horizon were conducted in 1986 and are described by Peterson, Lagus and Lie (1987). Based on the assumption that the formation is saturated with brine and for the measured formation pore pressures, halite permeability of 10^{-9} darcy and a marker-bed-139 permeability of 10^{-8} darcy were interpreted.

3.6 <u>Brine, Gas, and Performance Assessment</u>

Before underground excavations at WIPP, salt beds were thought to be essentially dry with very small amounts of moisture contained within the halite crystals. Observations in WIPP excavations since 1983 revealed anomalous quantities of moisture appearing on the walls as encrustations, some stalactites hanging from the back (ceiling), and holes in the floor filling up with brine. It was not until 1986, however, when the idea that salt beds may be saturated with brine was first proposed. Bredehoeft (1986, 1988) proposed that a repository in salt will fill with brine once the ventilation of the facility ceases to remove moisture. For a permeability of 10^{-8} darcy, he calculated the rate of inflow to be of the order of 0.01 liter/day/meter of tunnel. This would provide sufficient brine to saturate the closing rooms of the repository in a few hundred years.

Anderson (1987) calculated the effect of this hypothesis on long-term integrity of the WIPP repository and concluded 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. Subsequent work by Nowak, McTigue and Beraun (1988) found the "expected" brine accumulation in a WIPP disposal room in 30 years to be in the range of 4 m^3 to 43 m^3 whereas an estimated 900 m^3 is required for saturation of waste and backfill during this period. These calculations are, however, based on a number of assumptions of definite values of several key parameters which have a wide range and associated uncertainties. Nowak, McTigue and Beraun (1988) assumed formation permeability of 10^{-9} to 10^{-8} darcy (10^{-21} to 10^{-20} m^2), a porosity of 0.001, a Darcy-flow assumption for movement of brine through salt, storage due to linearly elastic compression of the salt and brine, a rate of host-rock creep resulting in complete reconsolidation in about 100 years, and the initial pore pressure to be between hydrostatic and lithostatic. Changes in the values of these parameters will change the calculated brine inflow values significantly.

The value of the permeability of the repository formation is a key parameter that affects the calculated values of brine inflow. Nowak, McTigue and Beraun (1988) calculated that increasing the permeability from 10^{-9} darcy to 10^{-8} darcy increases the brine inflow by a factor of 4 or 5. The highest assumed valve of 10^{-8} darcy is primarily based on a statistical argument and in situ measurements reported by Peterson, Lagus and Lie (1987), who stated (p.42), "While the data can be interpreted to yield free field pore fluid pressure and formation permeability values, the results are not conclusive." Other arguments to support the contention that the maximum brine-inflow calculated by Nowak, McTigue and Beraun (1988) is not necessarily the maximum amount, are presented in Chaturvedi, Channell and Chapman (1988, pp. 359-361; included as Appendix B of this report).

One of the important assumptions used by Nowak, McTigue and Beraun (1988) was that the WIPP disposal rooms would be virtually completely reconsolidated due to host rock creep in about 100 years, preventing further accumulation of brine. In making this assumption, they did not consider the potential role of gas generated by waste in slowing the rate of creep of salt. If the salt permeability is indeed as low as assumed by Nowak, McTigue and Beraun (1988), lesser amount of brine will flow into the repository, but the dissipation of gas in the rock is also drastically reduced. It is now clear that an accurate prediction of physical-chemical-biological conditions in the repository would require predictive modeling of multi-phase conditions in the repository, with best available estimates of mechanical, hydrological, geochemical and biological parameters. Such modeling would provide a range of conditions, which then should be used to perform a probabilistic risk assessment to assess compliance with the EPA Standards (U.S. EPA, 1985).

The conclusions of Anderson (1987) were based on the brine-slurry problem without consideration of gas generation in the repository. Since then, WIPP scientists (e.g., Lappin et al., personal communication, and presentation to the NAS WIPP Panel, June 7, 1989) have examined the effect of gas pressurization on the repository and concluded that a gas generation rate of 0.1 mole/drum/year will exceed lithostatic stress and might be unacceptable. Present "best estimates" of gas generation rates are 2.55 moles/drum/year (Lappin et al., 1989, p. 4-10) and 5 moles/drum/year (this report, Section 3.3). These estimates are based on the best available information on microbial and corrosion produced gas generation rates and do not include radiolytic gas generation which may not be a trivial amount. It does not seem likely that experimental observation under long-term simulated conditions would yield a number for the rate of gas generation, that is substantially lower than the present estimates.

Unpublished work by WIPP scientists continues to show problems in meeting compliance with the EPA Standards. For example, Anderson (1989) included the following two statements:

> "Preliminary PA calculations suggest that human intrusion into a repository of current design may give rise to releases that could violate 40 CFR 191." (Result of a 4/21/87 Initial Sensitivity Analysis)
>
> "We cannot presently ensure that WIPP will comply with the standard for human intrusion scenario."

Presumably, these conclusions are influenced by the gas/brine problem, but the calculations leading to these statements have not been published.

In summary, the potential problem of gas pressurization has been recognized by the WIPP project scientists since 1979. Early (in 1986, 1987) calculations to assess compliance with the EPA Standards raised the possibility of not being able to meet compliance with the Standards. Efforts to define the parameters that contributed to the "brine slurry" problem showed that because of very low permeability of the repository host rock, if brine inflow is not a problem, gas pressurization most likely is. Intensive modeling effort by Sandia scientists between January and March 1989 (Lappin et al., 1989), in support of the Supplemental Environmental Impact Statement preparation, has more clearly outlined the nature of the problem. Because of the unavailability of multi-phase flow modeling codes, precise prediction of the consequences of gas pressurization cannot yet be made (Lappin, personal communication). However, sufficient information is now available to conclude that gas pressurization and/or brine inflow will most likely be deleterious to the integrity of the WIPP repository, tens of years after decommissioning. It seems prudent to find a solution to the problem in addition to further defining the problem itself.

3.7 Engineered Modifications

Chaturvedi, Channell and Chapman (1988) analyzed the potential problems due to the flow of brine into the repository and reached the following conclusions (p. 363):

"...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..."

It has become more clear since the publication of the above that some engineered modifications will be needed to reduce the potential problems of brine inflow and gas generation in the repository. Some thought has been given by the project scientists (Lappin et al., 1989, pp. 4-89 to 4-100) to employ engineered modifications to the waste, container, backfill or design, to reduce the amount of brine and gas in the repository. Much more theoretical, laboratory and large-scale experimental work is needed to ensure long-term integrity of the repository. The following discussion summarizes some of the proposed modifications and what may or may not be expected from them.

The simplest modification appears to be to design the backfill to absorb or consume brine and gas in some manner.

Thus, backfill additives such as calcium carbonate ($CaCO_3$), calcium oxide (CaO), potassium hydroxide (KOH), and sodium hydroxide (NaOH) could remove most of the carbon dioxide (CO_2) expected to be produced by microbial processes (Brush and Anderson, 1989). However, it is not a simple solution, because very large amounts of these chemicals would be required and the process will be complicated if brine is present (or not present in some cases). Addition of Manganese dioxide (MnO_2) and copper sulfate ($CuSo_4$) has been proposed to prevent production of hydrogen (H_2), but both create other problems. No backfill additive has yet been identified that can definitely solve the problem and do so without requiring huge amounts.

A more expensive set of solutions include reprocessing or repackaging the waste. These include compaction, shredding, addition of cement or chemical grouts in the waste, or incineration. Compaction will reduce the void space available for brine to occupy and thus reduce the potential problem due to brine inflow, but will not solve the gas problem. In fact, less void space would mean higher gas pressures for a given volume of gas. Also, significant reduction of bulk density of TRU waste will not be an easy task. Stiff metal waste and cemented sludges control the bulk density of these wastes and very high pressures will be required to further compact them. Shredding of metallic waste might be required prior to compaction.

Incineration of combustible waste would eliminate gas production from microbial and radiolytic reactions with the organics, but will not reduce the expected gas production due to corrosion of metallic drums and the metallic waste. In summary, no ideal solution to the brine and gas production through engineered modification has yet been identified. Much more effort needs to be made in this area.

4. EVALUATION OF THE PROPOSED EXPERIMENTS WITH WASTE

4.1 Documents Available

This evaluation is based on the following documents that have been provided by DOE.

* Draft Plan for the Waste Isolation Pilot Plant Test Phase: Performance Assessment and Operations Demonstration (DOE/WIPP 89-011), April, 1989 (Received by EEG, April 26, 1989).

* Addendum - Summary of Revision of the Draft Plan for the Waste Isolation Pilot Plant Test Phase: Performance Assessment and Operation Demonstration, 3 p., 2 Figures, 2 Tables (Received by EEG, June 6, 1989).

* Test Plan: WIPP In Situ Room-Scale CH-TRU Waste Tests, by Martin A. Molecke, June 5, 1989, Draft, with a "Note: This Test Plan has not yet been reviewed by a formal, external peer review group, nor signed-off by the DOE/WPO" (Received by EEG, June 7, 1989).

* Draft Test Plan: WIPP Bin-Scale CH-TRU Waste Tests (Draft for Review), May 8, 1989, Draft by Martin A. Molecke (Received by EEG, June 7, 1989).

* Responses to Questions Dated May 15, 1989, from the Environmental Evaluation Group, attachment to Jack B. Tillman letter to Robert H. Neill, dated July 11, 1989, 8 p. + 1 Figure (Received by EEG, July 13, 1989).

The only purpose of the proposed experiments is to measure the rate of gas generation by the waste. Three kinds of experiments are proposed: lab-scale, bin-scale, and room-scale. Description of the lab-scale experiments will be in a report by L. H. Brush that is under preparation, and, according to DOE, expected to be available in October, 1989. Evaluations of the bin-scale and room-scale proposed experiments follow.

4.2 Bin-Scale Tests

A test bin is tentatively defined (Molecke, 1989a) to have an external, rectangular shape of 44 inches long x 49 inches wide x 34 inches high with a calculated inner volume of about 42.4 ft^3. The dimension is selected to fit snugly in a standard waste box (SWB) for transportation. They will be fabricated of A36 mild steel plate, approximately $^1/_4$ inch thick, and painted on both sides. Each bin is designed to contain about 6 drum volume-equivalents of CH-TRU waste. The bin-scale test proposes to study the effects of several factors on gas-production rates. These factors include: aerobic and anaerobic atmosphere conditions; conditions before and after corrosion of the drums; impact of brine inflow; and impacts of waste interactions with salt, metals, backfill, and gas getter materials. The effects of these factors will be studied by adding brine, metal, backfill, and getters in different proportions in different bins. All test bins are proposed to have a closely controlled and sealed environment (internal atmosphere), with gas sampling ports, pressure gage and control systems, and internal temperature monitors. The waste will consist of newly generated and old waste; processed, inorganic sludges; and standard as well as compacted waste and come from the Rocky Flats Plant.

A total of 100 waste-filled test bins are proposed to be used for the test with an additional eight waste-filled bins for contingencies. Since several of these drums will contain super-compacted waste, the total drum-volume-equivalent of actual 55-gallon, non-compacted waste will be approximately 896 [(64 non-compacted x 6) + (30 processed sludges x 4) + (14 super-compacted x 28)]. These tests are expected to start providing significant data within weeks to months after initiation of the test. The test is proposed to continue for about two to five years, or until the data acquired are sufficient to provide confidence in the reliability of the information being obtained. According to U.S. DOE (1989c, Vol.1, p. S-7), these tests can be performed at any one of several DOE locations and do not have to be performed at WIPP. If performed at WIPP, it is proposed to emplace all the bins in Room 1 of Panel 1. The emplacement will be in two phases; 32 bins will be emplaced in Phase I and will simulate conditions during the 25-year operational-phase of the repository. These will contain either no backfill or only salt/bentonite backfill without getters or special additives. Phase II will use up to 68 bins and these will simulate the long-term conditions by incorporating various proportions of brine, backfill, getters, and metal. Fourteen of these bins in Phase II will contain super-compacted waste.

Initiation of Phase II bin-tests will depend on supporting laboratory data and the availability of super-compacted wastes from the Rocky Flats Plant. The laboratory tests will be performed according to the plans yet to be described, and their results will help determine what quantities and compositions of gas getters or other backfill materials to use for these tests.

The proposal for bin-scale tests has apparently resulted from the criticism of DOE's 1988 plan for experiments (see Appendix D). These tests will study the interaction between various factors and can be expected to yield meaningful data. To be of use for the performance assessment calculations, however, the data should be available as soon as possible. Given the expressed urgency for such data, it is surprising that DOE has not begun these tests at any of the generator sites by now. If these tests had been initiated in late 1987, when the significance of the gas issue had been realized, at least some data would have been available by now. These experiments cannot begin at WIPP until the DOE has received authorization from EPA to ship mixed waste to WIPP, which may not be available until April 1990 or later.

4.3 Room-Scale Tests

The room-scale tests propose to utilize six "alcoves" or rooms, each about one-fourth (in volume) of the regular (300' x 33' x 13') room size. Each alcove will be 100' x 25' x 13' and will have the capacity to store about 1,100 drums of CH-TRU waste. Five alcoves will contain wastes and one will remain empty to serve as a gas baseline alcove. It is proposed to conduct the room-scale tests in two phases. Phase I will include emplacing CH-TRU waste in one alcove. Alcove 1 will be an empty, baseline alcove. Alcove 2 will contain a representative mixture of 1050 "as received" CH-TRU waste drums. Alcove 3 and 5 will contain "specially prepared" non-compacted waste. Alcove numbers 4 and 6 will contain "specially prepared" supercompacted waste. Only the Alcoves 5 and 6 will be backfilled, others will not be backfilled. The "specially prepared" waste will have the plastic bags breached by slicing or slashing, and the waste will be sandwiched between added layers of backfill (70% salt, 30% bentonite) and corrodant materials (mild steel wire mesh). After emplacement at WIPP, small amounts of the Salado brine will be injected into each waste container. All waste containers used in these tests will be vented, although the plastic bags in the Phase I alcove will not be breached.

Four test alcoves to be used for these tests are being mined north of the N1600 drift of Panel 1. A 50 foot long and 14 foot wide entryway will lead to each alcove (these dimensions are proposed by Molecke, 1989b; however, according to a DOE drawing, #51-W-099-W, the entryways are being mined to be 170 feet long).

A pneumatic plug-seal, the specific design of which has not yet been developed, will be fitted in each entryway to each alcove. A closed-loop gas circulation system will be installed through the plug-seal to assure proper mixing of the gases generated, to maintain anoxic conditions in alcoves 3, 4, 5, and 6, to allow injection of tracer gases, and to monitor for potential radioactive particulate contamination. Monitoring of the gases will be performed from the ductwork outside the plug-seal. The gas samples will be analyzed using an on-site gas chromatograph.

Firm schedules for these tests have not yet been developed. According to Molecke (1989b), development of schedules "requires further DOE/WPO and Sandia discussions with Rocky Flats Plant, Idaho National Engineering Laboratories and other CH-TRU waste generators/shippers" (p. 95). However, Figure 2-11 of U.S. DOE (1989a) shows that alcoves 5 and 6 of Phase II will be filled during FY '93. This will leave no time for the results of these tests to be available for use in performance assessment calculations, unless they are filled much earlier.

In summary, a total of five alcoves with approximately 1,100, 55-gallon CH-TRU waste drums, or equivalent, in each alcove are proposed for <u>in situ</u> measurements of the types and quantities of gases to be generated from these wastes. One alcove will contain waste without breaching the plastic liners and without the waste coming in contact with salt, brine, backfill, or getter material. The other four alcoves will contain wastes with breached liners and backfill, brine, and corrosive metal will be added to the drums. Special kinds of backfill materials are not planned to be used for these alcoves, as in bin-scale tests.

4.4 <u>Evaluation of the Experimental Plans</u>

The details of the experimental plans are not yet completed and DOE has not yet approved the specific plans. The main concerns with the plans are outlined below.

1. The experiments will most likely not provide a gas generation number that is substantially below the present estimates (2.5 or 5 moles/drum/year). Since the amount of gas generation that causes problems in predicting satisfactory performance is much lower (0.1 mole/drum/year), the experiments will most likely not help in showing compliance with the EPA Standards (40 CFR 191). However, the results may help in determining the extent of engineered modifications to meet compliance with the Standards. Since the experiments cannot be duplicated without another extensive effort lasting several years more, DOE may find itself with data that simply reinforce the prediction of problems in long-term safety.

2. Even if it is possible to start shipping the waste to WIPP in April, 1990, at best only partial data will be available from the proposed experiments by mid-1992. The experiments, as planned, may not provide reliable data in time for use in performance assessment calculations. Also, it is not clear that sufficient quantity of gas is likely to be produced to provide quantitative data when measurement sensitivities,

uncertainties, and the background concentrations are considered.

3. The three scales of proposed tests, viz. laboratory, bin-scale and room-scale, do not appear to be coordinated to provide complimentary information. The laboratory experiments should be performed first to provide information for better design of the other two, but they are not yet developed (the laboratory experiment plan will not be available until October, 1989, according to DOE). The bin-scale experiments are designed to study the effect of various factors on gas generation. The plan (U.S.DOE, 1989a) claims that these combination of tests will show scaling effects but does not explain how this will be done.

4. The experiments are designed to study the gas generation rates only. A good opportunity is being missed to also study the effect of engineered modifications on limiting the production of gas (and brine) or controlling it. The scope of bin-scale experiments can and should be enlarged to study the engineered modifications.

5. If it is necessary to obtain gas generation data, precious time has been wasted by not preparing to start the bin-scale experiments at the Rocky Flats Plant site.

6. The seal design for the room-scale experiment has not yet been developed and may provide a major source of uncertainty in interpretation of data. If the leakage is noted through the use of tracer gases, it would not be clear whether the escape route is provided by diffusion, fractures in the alcoves, rock bolts, or seals in the entry ways. Also, the formation might contribute gas in the alcoves and this will complicate

the interpretation of results. In fact, the specified tolerance leak rate (0.04 ft^3/min) for each alcove exceeds the expected gas generation rates.

5. CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

The following salient points emerge from this analysis of DOE's plans for the Five Year Test Phase for WIPP.

1. Even though DOE has always maintained the need for a five year research and development period for WIPP, the experiments that require transuranic waste were not identified until 1988. The previous R & D plans only proposed experiments with high-level waste.

2. Since experiments with TRU waste were first proposed in 1988, the amount identified has varied from 0.5% to 15% of the total WIPP inventory. Current plans call for approximately 0.5% for gas measurement and 2.5% for Operational Demonstration.

3. EEG does not see a need for shipping any waste to WIPP for operational demonstration before the facility can be demonstrated to meet EPA Standards for safe disposal of TRU wastes (U.S. EPA, 1985, or a revised version).

4. No experiments with remote-handled transuranic waste (RH-TRU) have been identified.

5. Detailed DOE-approved plans for the CH-TRU experiments are not yet available. Plans for the lab-scale experiments are not available even in draft form. Plans for the bin-scale and room-scale experiments are available as preliminary drafts, not approved by DOE. This analysis is based on the material available to EEG through September 15, 1989.

6. DOE's scientists responsible for assessing WIPP's compliance with the EPA Standards (U.S. EPA, 1985) have stated at technical meetings that it may be difficult to meet compliance with the standards for human-intrusion scenarios. No calculations for reaching such conclusions have yet been published. In fact, DOE has not even published a report listing the scenarios to be considered for such assessments.

7. The problem in meeting compliance with the EPA Standards results from the brine inflow from the rock and gas generation from the waste. If the formation is assumed to have an extremely low permeability, gas pressurization becomes a critical issue. At somewhat higher permeabilities, brine inflow becomes more important. It is necessary to perform and publish probabilistic calculations of breach scenarios and a sensitivity analysis of factors involved, to judge the relative importance of various factors.

8. A not-so-conservative estimate of gas production from TRU waste is 2.5 to 5 moles/drum/year. On the other hand, a rate of 0.1 moles/drum per year creates problems in performance assessment by raising the pressures in the repository to lithostatic (rock) pressure level at that depth. Therefore, the proposed gas experiments have to demonstrate that gas production is 25 to 50 times less than the current best estimate, for the issue to be not critical. This does not appear likely.

9. Since the problem has been identified and is not likely to be resolved by further experimentation to refine the value of one parameter, it seems more important to explore ways to solve the problem. Mitigation measures to reduce the effect of brine inflow and reduce the

amount of gas generation should be investigated. This includes theoretical, laboratory, and large-scale studies to evaluate various engineered modifications to the waste containers, backfill, repository design, etc.

10. If it is desired to obtain more data on gas generation, bin-scale experiments appear far better conceived and likely to yield better quality data than the room-scale tests. Sufficient good quality data is not likely to be available, however, for use in assessing compliance with the EPA Standards.

5.2 Recommendations

1. DOE must publish the analyses that form the conclusions stated by DOE scientists at several presentations that WIPP has problems in showing compliance with the EPA Standards. In addition, a range of scenarios for breach should be analyzed and published, to isolate the factors that need to be better understood or for which mitigation measures must be developed.

2. A realistic assessment of the effect of gas generation should be made. While the assumed "best estimate" of 2.55 moles/drum/year made by Lappin et al., (1989) is one-half of the "best estimate" using the same data (this report, p. 15), the predicted pressures (Lappin et al., 1989) in the repository (Table 2) are still too high. A more realistic assessment would consider the amount of brine that would be available; total time for bacterial action, radiolysis and corrosion; and the inter-relationship between different mechanisms of gas production. A better prediction of what may happen when the pressure in the repository begins to exceed the lithostatic pressure is also needed.

3. Based on the information to-date, it seems very likely that some engineered modifications will be needed to assure long-term integrity of the WIPP repository. Theoretical and experimental studies for possible modifications should begin immediately.

4. Based on the assumption that additional data may help in making better predictions, planning should continue for designing the gas experiments. The bin-scale experiments should be expanded to include the study of engineered modifications, including various kinds of getters and modified waste forms (cemented, incinerated, etc.) and should begin without further delay. The plan for alcove tests needs more refinement to establish that there is a possibility of obtaining quantitative data in time for performance assessment and that experimental problems (e.g., room sealing) are manageable. In proceeding with these experiments, however, it should be kept in mind that the results will most likely not help in showing compliance with the EPA Standards.

6. REFERENCES

Anderson, D. R., 1987, Preliminary performance assessment calculations of releases resulting from selected drilling scenarios, Presentation to the National Academy of Sciences WIPP Panel, September 22, 1987, Idaho Falls, Idaho.

Anderson, D. R., 1989, Performance assessment presentation to the U.S. Department of Energy, Advisory Committee on Nuclear Facility Safety, June 30, 1989, 16 view graphs, Sandia National Laboratories.

Bredehoeft, J. D., 1986, Hydrology of saturated salt, Presentation at the National Academy of Sciences WIPP Panel Meeting, Palo Alto, California, February 5, 1986.

Bredehoeft, J. D., 1988, Will Saturated repositories be dry?, EOS, Trans. Am. Geophysical Union, Vol. 69, No. 9, pp. 121-131.

Brush, L. H. and Anderson, D. R., 1988, Potential effects of chemical reactions on WIPP gas and water budgets, App. A.1, in Lappin et al., Systems analysis, Long-term radionuclide transport, and dose assessments, WIPP, SENM, SAND89-0462, April 1989.

Chaturvedi, L., Channell, J. K., and Chapman, J. B., 1988, Potential problems resulting from the plans for the first five years of the WIPP project, Waste Management '88, Tucson, Arizona, February 28-March 3, 1988, Vol. 2, p. 355, Arizona Board of Regents.

Clements, T. L. and Kudera, D. E., 1985, TRU waste sampling program, Idaho National Engineering Laboratory, EG&G Report, EGG-WM-6503, 2 vols.

Cooley, C. H., S. W. Butters, and A. H. Jones, 1978, Permeability of rock salt to gases and liquids, TR78-62, prepared for Sandia National Laboratories, Albuquerque, New Mexico.

Cooley, C. H., and S. W. Butters, 1979, Pressure time effects on permeability of salt cores, TR79-45, prepared for Sandia National Laboratories, Albuquerque, New Mexico.

Environmenal Evaluation Group, 1989, Review of the Draft Supplement Environmental Impact Statement, DOE-WIPP, EEG-41, DOE/AL/10752-41, 108 p.

Haberman, J. H. and Frydrych, D.J., 1988, Corrosion studies of A216 grade WCA steel in hydrothermal magnesium-containing brines, in M. J. Apted and R. E. Westerman, eds., Scientific basis for nuclear waste management XI, Proceedings of the Materials Research Society Symposium, v. 112, pp. 761-772.

Lappin, A. R., 1988, Summary of site-characterization studies conducted from 1983 through 1987 at the Waste Isolation Pilot Plant (WIPP) Site, Southeastern New Mexico. Sandia National Laboratories Report, SAND88-0157.

Lappin, A. R. and Hunter, R. L. (eds.), 1989, Systems analysis, long-term radionuclide transport, and dose assessments, Waste Isolation Pilot Plant (WIPP), Southeastern New Mexico: March 1989, Sandia National Laboratories Report, SAND89-0462.

Matalucci, R. V., 1987, Summary report: The integrated in situ testing program for the Waste Isolation Pilot Plant (WIPP), Sandia National Laboratories Report, SAND86-2716.

Matalucci, R. V., Christensen, C. L., Hunter, T. O., Molecke, M.A., and Munson, D.E., 1982, Waste Isolation Pilot Plant (WIPP) research and development program: In situ testing plan, March 1982, Sandia National Laboratories Report, SAND81-2628.

Molecke, M. A., 1979(a), Gas generation from transuranic waste degradation: An interim assessment, Sandia National Laboratories Report, SAND79-0117.

Molecke, M. A., 1979(b), Gas generation from transuranic waste degradation: Data summary and interpretation, Sandia National Laboratories Report, SAND79-1245.

Molecke, M. A., 1984, Test plan: Waste package performance technology experiments for simulated DHLW, Sandia National Laboratories.

Molecke, M. A., 1986, Test plan: WIPP CH and RH TRU waste technology experiments, Sandia National Laboratories.

Molecke, M. A., 1989(a), Draft test plan: WIPP bin-scale CH-TRU waste tests, Draft for review, May 8, 1989, Sandia National Laboratories.

Molecke, M. A., 1989(b), Test plan: WIPP in situ room-scale CH-TRU waste tests, Revised-formal peer review edition, June 5, 1989, Sandia National Laboratories.

Molecke, M. A. and Wicks, G. G., 1986, Test plan: WIPP materials interface interactions test (MIIT), Sandia National Laboratories.

Molecke, M. A. and Munson, D. E., 1987. Test plan appendix: WIPP simulated RH TRU waste add-on tests. Sandia National Laboratories.

National Research Council/National Academy of Sciences, Panel on the Waste Isolation Pilot Plant, 1984, Review of the scientific and technical criteria for the Waste Isolation Pilot Plant (WIPP), DOE/DP/48015-1.

Neill, R. H. and Chaturvedi, L., 1989, Technical and programmatic evaluation of WIPP, Waste Management '89, Tucson, Arizona, February 26-March 2, 1989, Vol. 1, p. 253, Arizona Board of Regents.

Nowak, E. J., McTigue, D. F. and Beraun, R., 1988, Brine inflow to WIPP disposal rooms: Data, modeling, and assessment, Sandia National Laboratories Report, SAND88-0112.

Nuclear Packaging, Inc., 1989, Safety analysis report for the TRUPACT-II shipping package, submitted to the Nuclear Regulatory Commission, Docket Number 71-9218, August, 1989, 5 Vol.

Peterson, E. W., P. L. Lagus, R. D. Broce, and K. Lie, 1981, In situ permeability testing of rock salt, SAND81-7073, prepared for Sandia National Laboratories, Albuquerque, New Mexico.

Peterson, E. W., P. L. Lagus, J. Brown, and K. Lie, 1985, WIPP horizon in situ permeability measurements, SAND85-7166, prepared for Sandia National Laboratories, Albuquerque, New Mexico.

Peterson, E. W., P. L. Lagus, and K. Lie, 1987, WIPP horizon in situ permeability measurements, SAND87-7164, prepared for Sandia National Laboratories, Albuquerque, New Mexico.

Powers, D. W., Lambert, S. J., Shaffer, S. E., Hill, L. R., and Weart, W. D. (eds)., 1978, Geological characterization report, Waste Isolation Pilot Plant site, southeastern New Mexico, Sandia National Laboratories Report, SAND78-1596.

Sandia National Laboratories, 1979, Summary of research and development activities in support of waste acceptance criteria for WIPP, Sandia National Laboratories Report, SAND79-1305.

State of New Mexico/U.S. Department of Energy, 1984, First modification to the July 1, 1981, Agreement for Consultation and Cooperation on WIPP, November 30, 1984, 15 p. + appendices.

Sullivan, B. R., reported in Black, S., R. Nausten, and D. Shakla, Eds., 1985, Results of the SPDV site validation experiment Waste Isolation Pilot Plant, TME-3177, prepared for U. S. Department of Energy.

Sutherland, H. J., and S. P. Cave, 1979, Gas permeability of SENM rock salt, SAND78-2287, Sandia National Laboratories, Albuquerque, New Mexico.

Tyler, L. D., Matalucci, R. V., Molecke, M. A., Munson, D. E., Nowak, E. J., and Stormont, J. C., 1988, Summary report for the WIPP technology development program for isolation of radioactive waste, Sandia National Laboratories Report, SAND88-0844.

U. S. Department of Energy, 1988(a), Panel One monitoring plan for the Waste Isolation Pilot Plant, Draft, March 1988.

U. S. Department of Energy, 1988(b), Department of Energy five-year test plan Waste Isolation Pilot Plant, Carlsbad, New Mexico, DOE/WIPP-88-015 (Draft), June 1988.

U. S. Department of Energy, 1989(a), Draft plan for the Waste Isolation Pilot Plant test phase: Performance assessment and operations demonstration, DOE/WIPP-89-011, April 1989.

U. S. Department of Energy, 1989(b), Project manager's progress report for the Waste Isolation Pilot Plant, WIPP-DOE-186, June 1989.

U. S. Department of Energy, 1989(c), Draft supplement environmental impact statement, Waste Isolation Pilot Plant, DOE/EIS-0026-DS, April 1989, 2 volumes.

U. S. Environmental Protection Agency, 1985, Environmental radiation protection standards for management and disposal of spent nuclear fuel, high-level and transuranic radioactive wastes, in Federal Register, vol. 50, no. 182, September 19, 1985, pp. 38084-38089.

Wade, T., 1987, Statement of Troy Wade, Acting Asst. Sec'y. for Defense Programs, DOE, before the Subcommittee on Public Lands, National Parks and Forests, of the U.S. Senate Committee on Energy and Natural Resources, October 12, 1987, Carlsbad, New Mexico.

Weart, W. D., 1987, Preliminary details of the WIPP radioactive tests (WRT), letter to W. R. Cooper, DOE/WPO, January 7, 1987, Sandia National Laboratories, referenced in Tyler et al., Summary Report for the WIPP Technology Development Program for Isolation of Radioactive Waste, SAND88-0844.

7. APPENDICES

7.1 Appendix A - Letter from EEG to DOE, dated 12/31/1987, requesting experimental plans for WIPP

"Equal Opportunity Employer"

HEALTH & ENVIRONMENT department

STATE OF NEW MEXICO

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December 31, 1987

Mr. Jack B. Tillman
WIPP Project Manager
WIPP Project Office
P. O. Box 3090
Carlsbad, NM 88220

Dear Mr. Tillman:

Confirming our telephone conversation today, the purpose of this letter is to request information now on the scientific research and development (R&D) experiments scheduled to be performed at WIPP on the CH-TRU waste during the first five years of operations. The Department has maintained that waste emplacement for the first five years is not disposal, but is R&D to demonstrate the safe disposal. As you know I have repeatedly requested this information for over a year. At the October 12, 1987, Senate Hearings in Carlsbad, Mr. Troy Wade, Assistant Secretary of Defense Programs, stated that waste emplacement during this period was R&D. At the joint meeting between DOE and EEG two days later no one on your staff could provide any information on the experiments. At the NAS Meeting in Idaho in June, you agreed to provide that group with information on the experiments at the December meeting. At the December meeting in Albuquerque, no information was presented.

The reason I am requesting this technical information now is to fulfill EEG's responsibilities to inform the State policymakers at the January 13, 1988 Task Force Meeting in determining the applicability of the timing of the EPA standard 40CFR191 Subpart B during the five-year period of waste emplacement.

At the October 12, 1987 hearing, Dr. Wendell Weart stated that four rooms would be needed for experiments measuring gas generation. We have heard nothing further on this subject.

If only four rooms are required for experimental purposes of R&D, that amounts to 25,000 drums or 3% of the total waste to be emplaced at WIPP. Since an emplacement of 15% of the waste during the first five years amounts to 125,000 drums, what are your plans for R&D for the remaining 100,000 drums during this period? If there is no technical documentation or justification for R&D or experiments for these 100,000 drums, then the implication is that the emplacement is disposal. I need to clarify this now in order to inform the policymakers in fulfilling their responsibilities.

Sincerely,

Robert H. Neill
Director

cc: T. Bahr
L. Gordon
M. Burkhart

7.2 Appendix B - Chaturvedi, Channell, Chapman, "Potential problems resulting from the plans for the first five years of the WIPP project," presented at Waste Management '88 symposium in Tucson, Arizona on March 2, 1988 and published in the Proceedings, Vol. 2, of the symposium, pp. 355-364.

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 ten 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 4,250 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 (1,000 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, but 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 eight "panels" with seven "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 three high in the rooms and in the drifts connecting the rooms and in boxes. RH-TRU waste will be

(Waste Management '88, Edited by R. G. Post and M. E. Wacks, vol. 2)

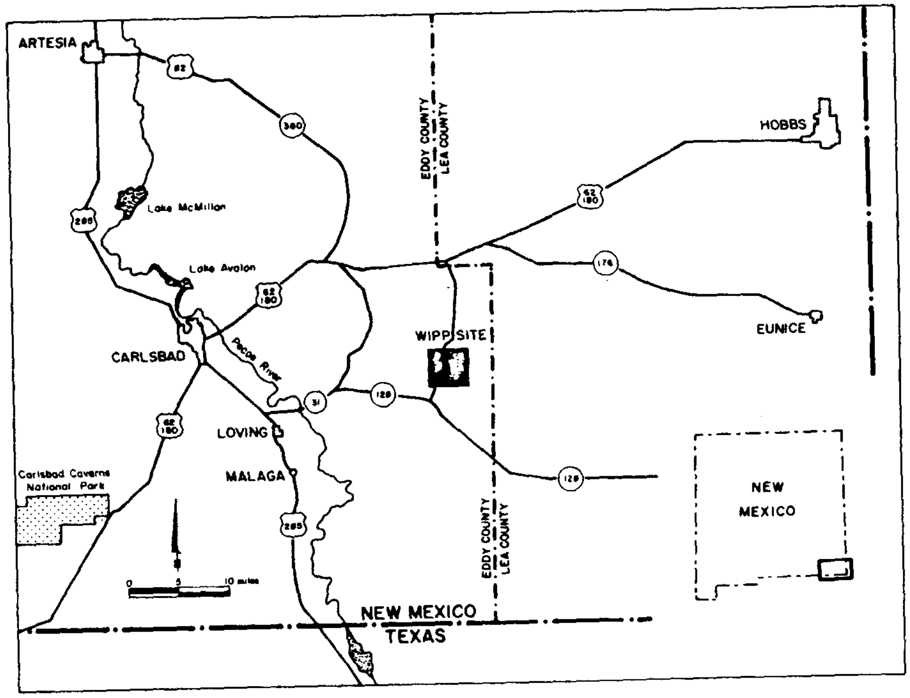

Fig 1. Location of the WIPP Site.

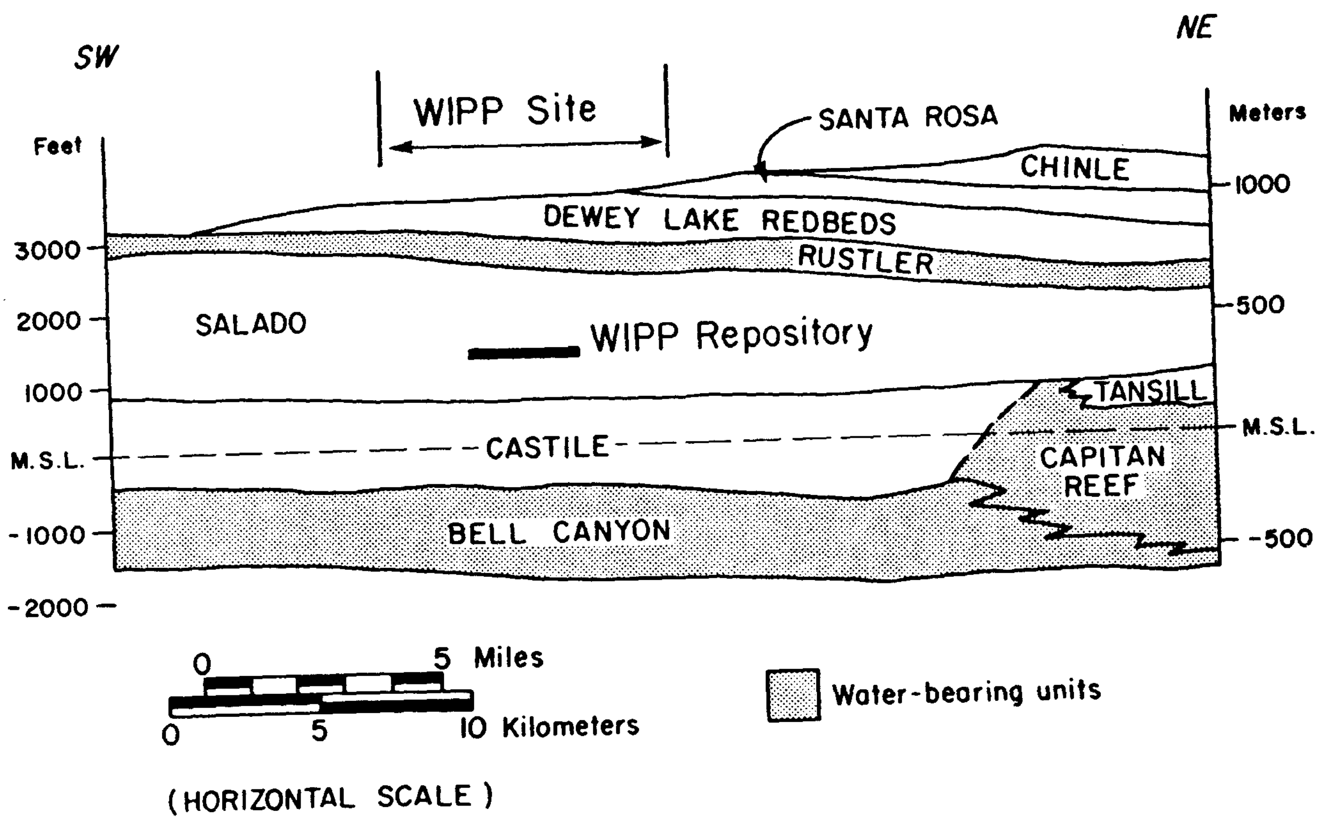

Fig. 2. Generalized Geologic Cross-Section at the WIPP Site.

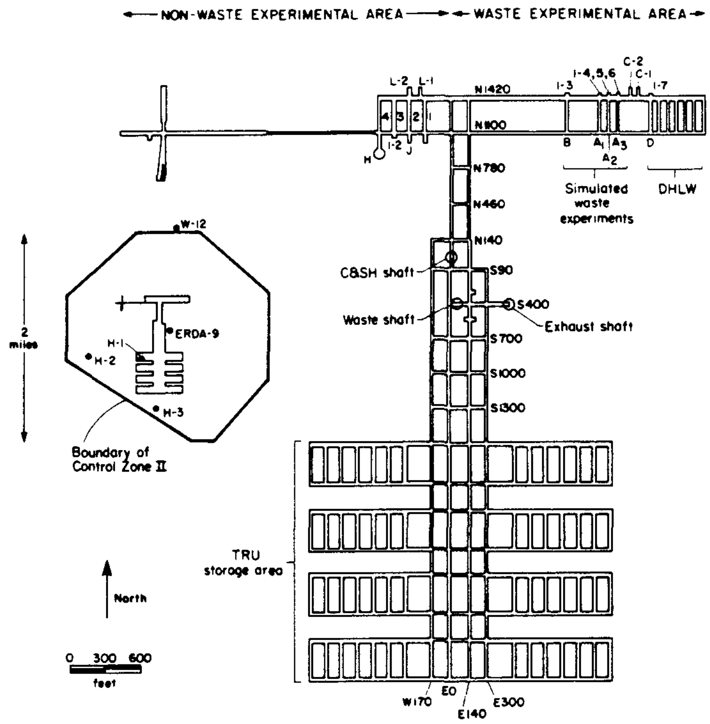

Fig. 3. Underground Layout of the WIPP Repository and the Experimental Area.

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 five to ten 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 three to five 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 five years of waste and a careful analysis of the situation in 1986 resulted in five design modification options (4) as follows:

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

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

3. Excavate the rooms to 14 x 34 feet and trim again to that dimension after one years. Complete retrieval within six 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

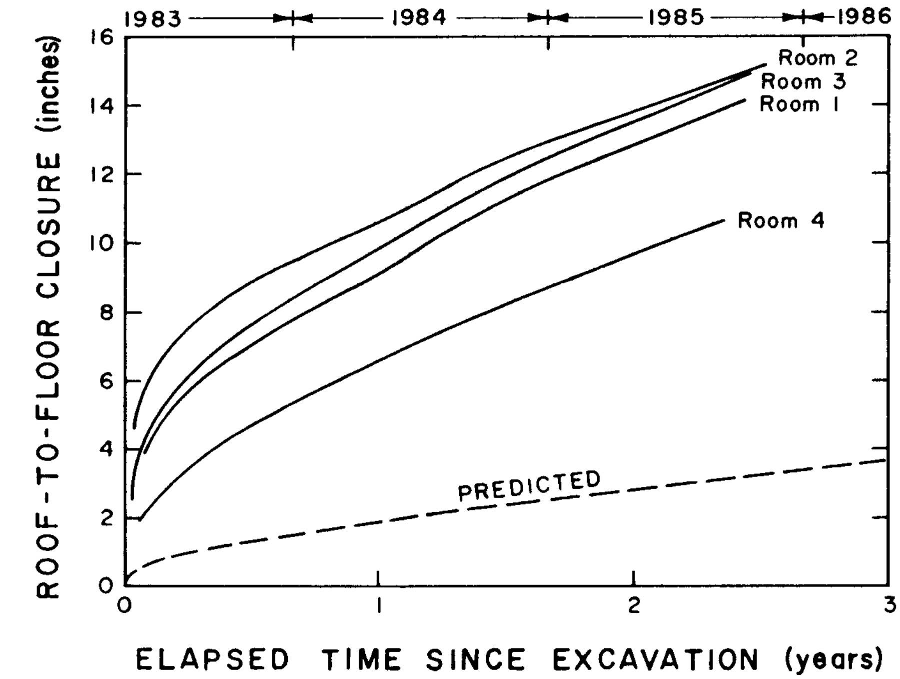

Fig. 4. Roof-to-Floor Closure Rate of the Experimental Rooms at WIPP.

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 five year retrievability. DOE therefore made a decision to defer emplacement of backfill until after five 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 seven-pack drums along the width of a room or drift.

After five years, a waste room 300 ft. long, 33 ft. wide, and 13 ft. high would be filled with 6,000 drums of CH-TRU waste stacked three drums high. The distance between the ceiling and the top of the drums would be barely two 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 ten 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 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. Must 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 one 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 one 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

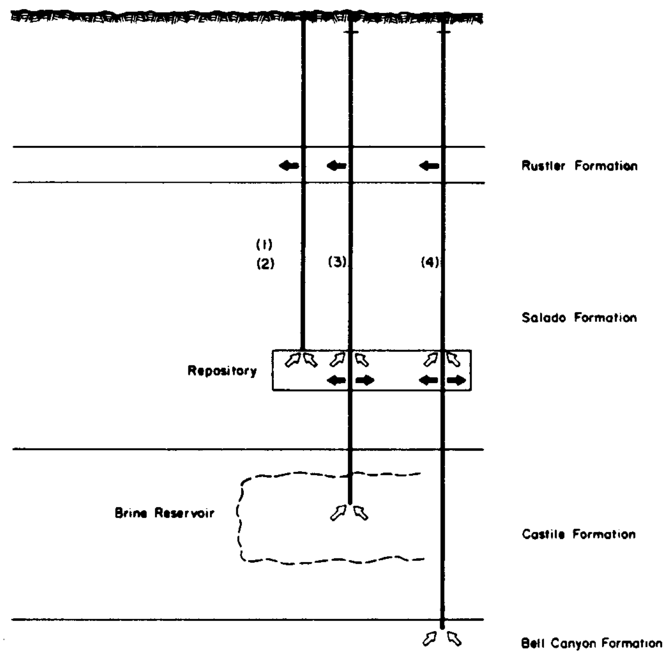

Fig. 5. Postulated Breach Mechanisms of the WIPP Repository.

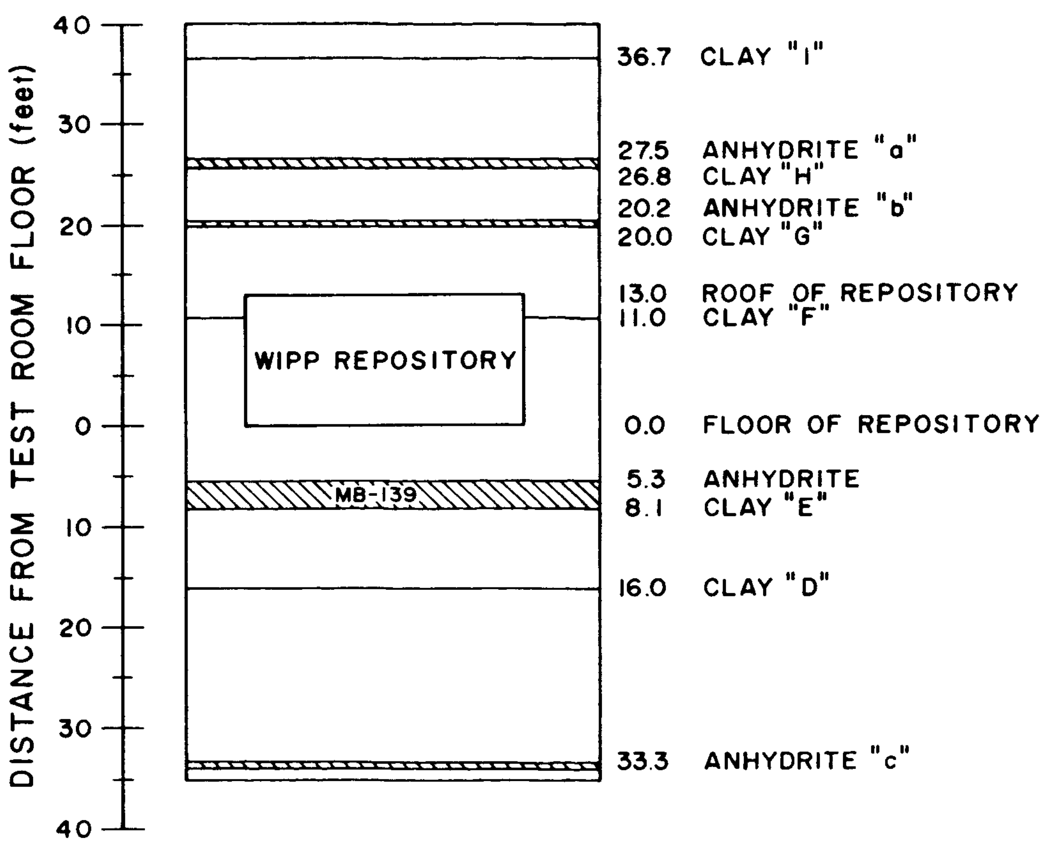

Fig. 6. Clay and Anhydrite Layers Immediately Above and Below the WIPP Repository.

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 5×10^{-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 5×10^{-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 abe 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 unsaturatead 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:

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

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 as 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 area 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 Date 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 (3.96 m) 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 three rows of stacked 7-packs, 21-27 7-packs, and portions of seven TRUPACT loads. The larger cylinder would intersect five rows, the entire width of the room, 12 full TRUPACT loads and one partial load. The results are shown in Table I.

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 1,240 years for 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-to-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

TABLE I

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

Waste Sources	% Total Waste Volume	Average α Ci/TRUPACT	Number of TRUPACT's 45 m^3	Number of TRUPACT's 200 m^3	α Curies Reaching Surface 45 m^3	α Curies Reaching Surface 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

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.

REFERENCES

1. U. S. DEPARTMENT OF ENERGY, "Final Environmental Impact Statement, Waste Isolation Pilot Plant," DOE/EIS-0026, (1980).

2. D. E. MUNSON and A. F. FOSSUM, "Comparison Between Predicted and Measured South Drift Closures at the WIPP Using a Transient Creep Model for Salt," Proc. 27th U. S. Symp. Rock Mech., Tuscaloosa, Alabama, 1986, p. 931, American Institute of Mining Engineers (1986).

3. H. S. MORGAN, C. M. STONE, and R. D. KRIEG, "An Evaluation of WIPP Structural Modeling Capabilities Based on Comparisons With South Drift Data," SAND85-0323, Sandia National Laboratories (1986).

4. BECHTEL NATIONAL, INC., "Waste Isolation Pilot Plant Design Validation Final Report," DOE-WIPP-86-010, U. S. Department of Energy (1986).

5. J. D. BREDEHOEFT, "Is WIPP Salt Dry An Alternative Hypothesis, submitted to EOS, Trans., Geophysical Union, (1988).

6. EARTH TECHNOLOGY, INC., "Final Report for Transient Electromagnetic (TEM) Survey at the WIPP Site," SAND87-7144, Sandia National Laboratories (1988).

7. L. CHATURVEDI and K. REHFELDT, "Groundwater Occurrence and the Dissolution of Salt at the WIPP Radioactive Waste Repository Site," EOS, Trans., Am. Geophysical Union, 65, 457 (1984).

8. J. K. CHANNELL, "Calculated Radiation Doses from Radionuclides Brought to the Surface if Future Drilling Intercepts the WIPP Repository and Pressurized Brine," EEG-11, Environmental Evaluation Group (1982).

9. S. T. BARD, "Estimated Radiation Doses Resulting if an Exploratory Borehole Penetrates a Pressurized Brine Reservoir Assumed to Exist Below the WIPP Repository Horizon: A Single Hole Scenario," EEG-15, Environmental Evaluation Group (1982).

10. R. ANDERSON, "Preliminary Performance Assessment Calculations of Releases Resulting From Selected Drilling Scenarios," Presentation to the National Academy of Sciences WIPP panel, September 22, 1987, Idaho Falls, Idaho (1987).

11. E. J. NOWAK, "Assessment of Brine Inflow to WIPP Disposal Rooms," Sandia National Laboratory (1988).

12. D. E. DEAL and J. B. CASE, "Brine Sampling and Evaluation Program, Phase I Report," DOE-WIPP-87-008, U. S. Department of Energy (1987).

13. J. C. STORMONT, E. W. PETERSON and P. L. LAGUS, "Summary of and Observations About WIPP Facility Horizon Flow Measurements Through 1986, SAND87-0176, Sandia National Laboratories (1987).

14. E. J. NOWAK and D. F. McTIGUE, "Interim Results of Brine Transport Studies in the Waste Isolation Pilot Plant," SAND87-0880, Sandia National Laboratories (1987).

15. E. W. PETERSON, P. L. LAGUS, and K. LIE, "WIPP Horizon Free Field Fluid Transport Characteristics," SAND87-7164, Sandia National Laboratories (1987).

16. E. W. PETERSON, P. LAGUS, and K. LIE, "Fluid Flow Measurements of Test Series A and B for the Small Scale Seal Performance Tests," SAND87-7041, Sandia National Laboratories (1987).

17. E. PETERSON, P. LAGUS, J. BROWN, and K. LIE, "WIPP Horizon In SITU Permeability Measurements Final Report," SAND85-7166, Sandia National Laboratories (1985).

18. SANDIA NATIONAL LABORATORIES, "Summary of Research and Development Activities in Support of Waste Acceptance Criteria for WIPP," SAND79-1305, Sandia National Laboratories (1979).

7.3 Appendix C - Letter from EEG to DOE, dated May 11, 1988, seeking clarifications on "Panel 1 Monitoring Plan" report.

HEALTH & ENVIRONMENT department

"Equal Opportunity Employer"

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May 11, 1988

Mr. Jack B. Tillman
Project Manager
WIPP Project Office
U. S. Department of Energy
P. O. Box 3090
Carlsbad, New Mexico 88221

Dear Mr. Tillman:

We have reviewed the draft report, "Panel One Monitoring Plan for the Waste Isolation Pilot Plant." Although we agreed at the April 28th Quarterly Meeting to discuss our questions at a May 10, 1988 meeting, subsequent postponement by DOE to about May 18 prompts these questions now. While we have some questions regarding details on the "Structural Response" and "Brine Seepage" Monitoring Plans, this letter is confined to the clarifying questions concerning the experiments for which radio-active waste is required to be stored in the repository. I will appreciate receiving replies to the following questions from you at our meeting or at your earliest convenience.

1. The report does not identify any experiments requiring RH-TRU waste and only states, "The need for an RH-TRU Monitoring Plan is being evaluated." When will DOE be able to provide us with an RH-TRU monitoring plan and an estimate of the quantities of waste required?

2. The report does not explain the need for about 6,000 drums of each of the four waste types. Also, why can't the four waste types be studied in one room divided into four compartments?

3. The environment in which the gas monitoring is proposed to be done will not represent the actual repository environment. There will be no backfill, brine will not be allowed to accumulate around the drums, the containers will not be breached and the rooms will not be pressurized by gas. Why not conduct the experiments in an environment that more closely represents the actual repository conditions? Under the conditions identified in the report, how will "the complexity of chemical, microbial, and radioloytic interactions" (p. 1-2) be studied? The report does not discuss the length of the gas monitoring experiments. How long will the monitoring continue? What are the plans for retrieval or re-emplacement of the waste?

4. The plan does not specify any level of leakage that would constitute a failure of the bulkhead seal, although leakage is expected and will be measured using neon (Ne). Shouldn't a predetermined minimum effectiveness be established for the bulkhead seal system? Furthermore, why not attempt to install leak tight bulkheads?

We have other specific comments on the details of the monitoring system that we will forward later. At this time, we are seeking clarifications on the broad issues of the need for experiments requiring waste, amount of waste required, and the plans for retrieval of this waste at the completion of these experiments.

Sincerely,

James K. Channell
Robert H. Neill
for Director

RHN:LC:ss

7.4 Appendix D - Letter from EEG to DOE, dated July 13, 1988, commenting on U. S. DOE (1988b).

ENVIRONMENTAL EVALUATION GROUP

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July 13, 1988

Mr. Jack B. Tillman
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Dear Mr. Tillman:

The following are the Environmental Evaluation Group comments on the "Waste Isolation Pilot Plant Five-Year Test Plan" (DOE/WIPP 88-015) that you requested in your letter of June 16, 1988.

We expected this document to provide specific plans for experiments with waste and the justification for doing so. There are, however, only four pages that deal with the experiments requiring waste. The document lacks coherence and internal consistency. In order to provide meaningful comments, this letter is based on information that we have received from you during the past few months, in addition to the Five-Year Plan. This information includes the Panel 1 Monitoring Report and that provided at the DOE/EEG Quarterly Meeting (April 28), the meeting on Experimental Programs (May 25), the meeting on Brine Inflow (June 9), and the National Academy of Sciences WIPP Panel meeting in Irvine, California (June 28-29). Our comments are numbered to facilitate your response.

1. The "Panel One Monitoring Plan for WIPP" report that you provided to us in March, 1988, stated, "The need for an RH-TRU Monitoring Plan is being evaluated." From the discussion on page III-6-7 of the Five-Year Test Plan, we infer that you have completed your evaluation and have determined that there is no need to bring RH-TRU waste to WIPP during the R & D phase of the project since the only R & D experiment is for gas generation and the Five-Year Plan states that the contribution to gas from the RH-TRU waste will be accounted for by the CH-TRU waste. The Safety Analysis Report (SAR) is silent on any need for RH-TRU waste during the first 5 years, which comprises 36% of the radioactive waste inventory.

2. The only proposed experiment involving emplacement of waste at WIPP consists of 25,000 drums of CH-TRU waste for gas monitoring in five rooms of the first panel. As we have stated during our meetings and at the NAS meeting on June 29, we continue to remain puzzled by the scheduling inconsistency between the experimental plan and the need for the results. At our technical meetings, your staff emphasized the need for data to be obtained from gas monitoring for performance evaluation. The schedule on page III-6-6 indicates

that gas monitoring in the first room will not begin until October, 1989 and the final report on gas monitoring will not be issued until December, 1993. It appears most unlikely that gas monitoring, even in the first room, can begin in October, 1989 since you intend to obtain representative mixtures of weapons grade and Pu-238 heat source waste and the NRC plans to phase shipments of waste using the more dilute concentrations initially. How do you propose to get statistically meaningful results from five rooms for Performance Assessment that, according to the schedule shown in Figure II-4, requires "Final" data by the end of 1990?

3. Your plan places much emphasis on the interaction of gases produced from different drums and the effect of room temperature and humidity on gas generation from the drum. But the radioactivity and the bacteria which are the engines of the gas generation processes (along with some potential rusting and thermal sources of unknown significance) are situated in the system on substrates which are not merely in the drums, but are isolated in bags within bags, within liners, within the drums. Every effort will be made to ensure that this multilayer isolation remains intact. This would mean that the hoped for multilevel interaction between gases generated in a variety of drums and the gas generation sites either collapses entirely, or is constrained to be diffusion limited through several barriers. Consider the microbial gas generation, for example: how could the humidity of the repository influence bacterial growth if water vapor only very slowly permeates the filter, drum void, and then successive layers of plastic bags and containers? The amount of time required to achieve equilibrium for the various gases should be addressed which could markedly affect the availability of data for performance assessment.

4. The environment in which the gas monitoring is proposed to be done will not represent the actual repository environment. There will be no backfill, brine will not be allowed to accumulate around the drums, and the rooms will not be pressurized by gas. This means that while the gas measurements are relevant to the long range performance assessment, such measurements as proposed will be constrained to be only of the diluted diffusion limited and/or pressure driven portions of gases formed in the relatively isolated substrate environments in the drum. The most relevant measurements would be of gases which have ready access to both the waste substrates themselves, the brines, backfill, and repository masses, all under conditions which as closely as possible match the pressure and temperature conditions of the sealed repository.

5. As we have previously indicated to you, we are concerned about the plan to emplace a large quantity of unprocessed waste underground without backfill, unless the benefits from such emplacement clearly outweigh the potential risk to workers from having to later move the waste to emplace backfill and for potential reprocessing for permanent disposal. In the attachment to the Five-Year Test Plan, there is a statement about Engineered Fixes to safeguard against potential brine-related problems. It appears to us that a large quantity of waste should be emplaced only after a decision on the

engineering solutions to the brine problem has been made and a backfill has been selected. We are aware of your argument that experiments with waste are needed to make a decision on these matters, but you do not present any evidence to make that argument convincing in view of the questions posed above.

We are acutely aware of the fact that we have posed questions on your plans without providing suggestions or alternative plans. Frankly, after our meetings in May and June, we expected to receive a more defensible plan for experiments with waste because we have raised these matters several times during meetings for the past two years and through my recent letter of May 11. We do want to be helpful in resolving the question of meaningful experiments consistent with the ALARA concept, and will be happy to meet with you for yet another "brainstorming" session.

With regard to the experiments not involving waste, we have held several discussions with your staff and scientists from Sandia National Laboratory, Westinghouse Electric Corporation, and the IT Corporation. We will continue to provide our input on those tests through letters, reports, and meetings on various components of the experiments.

Sincerely,

Robert H. Neill
Director

RHN:ss

7.5 Appendix E - Letter from EEG to Mr. Troy Wade, Acting Assistant Secretary for Defense Programs, DOE, Dated January 17, 1989.

ENVIRONMENTAL EVALUATION GROUP

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7007 WYOMING BOULEVARD, N.E.
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January 17, 1989

Mr. Troy Wade
Acting Assistant Secretary for
Defense Programs
U. S. Department of Energy
1000 Independence Avenue S.W.
Washington, D.C. 20585

Dear Mr. Wade:

At the WIPP tour for the five Members of the U. S. House of Representatives in Carlsbad on January 11th, you commented that you did not understand my statement that EEG had not yet received proper justification from DOE to emplace any waste in WIPP for either research and development or for operational purposes. You pointed out that the Department's latest schedule calls for the provision of that information to us in March 1989, with a final report to be published in June 1989.

It has been 15 months since you testified in Carlsbad before the New Mexico Congressional delegation that the purpose of the proposed waste emplacement in WIPP was R&D, and most recently in September 8, 1988, Congressional testimony, that the experiments would provide data for performance assessment.

Copies of my December 31, 1987, and July 13, 1988, letters to the WIPP Project Manager documenting our repeated requests for specifics are enclosed. Actually, we have been requesting information for over two years on the information to be obtained from the experiments, the amounts required and the timing of the availability of data for performance assessment.

There was no purpose to be served in the limited time available to pursue the matter with you on January 11th, but it is important that you be aware of the absence of proper justification for temporary waste emplacement to date and of our efforts to urge DOE to develop such documentation.

Sincerely,

Robert H. Neill
Director
RHN:sld
Enclosure

7.6 Appendix F - Letter from EEG to DOE, dated May 15, 1989, seeking clarifications on the Test Phase Plan (U.S. DOE, 1989a).

ENVIRONMENTAL EVALUATION GROUP

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May 15, 1989

Mr. Jack B. Tillman
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P.O. Box 3090
Carlsbad, NM 88221

Dear Mr. Tillman:

We have been reviewing the "Draft Plan for the WIPP Test Phase: Performance Assessment and Operation Demonstration, DOE/WIPP 89-011, April 1989" that we received from you on April 26, 1989. We find that this document is incomplete and is internally inconsistent. Also, there are contradictory statements when compared to related DOE publications and public comments by DOE officials. Your prompt reply to the following questions will help us to comment constructively on this report.

1. Are the room-scale and bin-scale gas generation experiments designed to provide data necessary for performing the calculations to show compliance with the EPA Standards 40 CFR 191, or will the data be used only to confirm the predictions?

2. What is the basis for keeping the results of the preliminary consequence analysis for internal evaluation only (page 2-23)? The entire Performance Assessment portion of the plan is based on the claim that experiments with waste need to be performed to show compliance with 40 CFR 191, Subpart B, yet we are asked to comment on the plan without benefit of the preliminary work that has been done.

3. The Sensitivity and Uncertainty Analysis described on pages 2-23 to 2-25 must have been done in order to plan the experiments for performance assessment. Please let us have a copy of the "preliminary sensitivity study (that) identified the human - intrusion scenarios as critical" (page 2-24). This study is also reported (page 2-24) to have identified "gas generation" as one of the four "energy sources...that could move waste from the repository horizon to the accessible environment." The importance and

relevance of the proposed in situ gas generation experiments cannot be evaluated without first critically examining the sensitivity study.

4. The rate of closure of the excavations has been mentioned in several places in the report as a parameter for which more data needs to be obtained in order to proceed with the performance assessment calculations. We know that the rate of closure of the rooms and drifts, with and without heat, has been studied extensively at WIPP for the past six years, and there are a number of technical papers in the open literature on this subject. Even the discrepancy between the predicted and observed rates of closure has been explained by using different models for the mechanical behavior of salt. Why can't the performance assessment proceed without additional study of the room closure rates?

5. The schedule of the proposed experiments, data availability, time needed for completing the performance analysis calculations, and the availability of the results of performance assessment, has not been presented in a consistent manner in the document. Furthermore, the schedule for the events presented in this document is not consistent with other recently published DOE documents. We need your best and most current projection of the sequential schedule of these events in order to comment on the proposed program.

6. What is the projected schedule for the selection of backfill? What "experimental and performance assessment activities" (page 3-40) are required for this selection to be made and how? What is a "backfill emplacement demonstration" (page 3-40), and when and how will it be carried out? The text suggests that the backfill will not be selected until the backfill emplacement demonstration or the performance assessment is completed.

7. How and when will the "demonstration of seal performance" (page 3-40) be carried out? Will this demonstration include the room, panel, shaft, and borehole seals? Have the designs of the plugs and seals to be used for WIPP been completed? If not, when and how are these decisions to be made?

8. How will the retrievability of the experimental waste be ensured? Are you planning to perform another "mock retrieval demonstration" (page 3-42)? Experimental rooms #1 and #2, that were excavated in March and April 1983, have shown serious and continuous cracks in the ceiling and the walls and have been closed. Cracks in the floors of the experimental rooms were observed in October, 1985, only two and one-half years after their excavation. Since these rooms were excavated to the same dimensions as the waste

emplacement rooms and in the same stratigraphic horizon, their failure in six years does not provide much confidence in maintaining easy retrievability from the waste rooms for ten years (five years to emplace and five years to retrieve). What would be the disposition of the retrieved waste?

9. How will the decision be made on engineered modifications and waste treatment, if necessary to meet compliance with the EPA Standards? Would it not be advisable to begin experiments for these purposes now, rather than waiting until after the decision is made to incorporate engineered modifications or waste reprocessing in the design?

10. It is stated (page ES-1) that compliance with only Sections 13 and 15 of the EPA Standards, 40 CFR 191, will be demonstrated during the test phase. Why not Sections 14 and 16? In our opinion, compliance with Section 14 (Assurance Requirements) should have been demonstrated by now by developing the design for markers, etc., and by publishing a report to show that the favorable geologic conditions compensate for the presence of natural resources underground at WIPP. The determination that the site did not meet this requirement after the emplacement of 60,500 drums would not make sense.

11. Two conflicting layouts of the emplacement of waste during the test phase were presented to us during the DOE presentation of the Plan on April 21, 1989. The layout shown on page 3-41 does not match the layout presented by Martin Molecke, but the references to the test alcove numbers in the text appear to refer to the layout presented by Dr. Molecke at the meeting. What is the officially proposed layout?

12. The Waste Emplacement Schedule figure on the "Notice to Reader" page of the document shows a solid horizontal line from September, 1992, to September, 1994. Does this mean that no additional waste is proposed to be emplaced during that period of two years?

13. A draft test plan for WIPP Room-Scale CH-TRU Tests is scheduled to be available on April 1, 1989 (mid-FY 89), as stated on page 2-109. Similarly, a draft test plan for WIPP Bin-Scale CH-TRU Waste Tests is scheduled to be available sometime between October 1, 1988, and October 1, 1989 (FY 89), page 2-112. The three-page description (pages 2-106 to 2-109) of the Room-Scale Gas Generation Tests and a similarly brief description of the Bin-Scale Tests (page 2-110 to 2-112) does not provide "Details on the waste mix compositions, types and quantities of waste drums and backfills, getters, degradation product contaminants, extent of brine moistening,

atmosphere control (aerobic/anaerobic, pressures), instrumentation and control hardware, and emplacement schedules..." (pages 2-109 and 2-112). It would not be possible for us to comment on the suitability and the adequacy of your plans for experiments with waste without considerably more details and consistency.

14. The following reference, cited in Appendix A, is needed to understand the plans for laboratory and modeling studies of repository and radionuclide chemistry. Please make this report available as soon as possible.

> Brush, L.H., 1989, (in preparation). "Test Plan for Laboratory and Modeling Studies of Repository and Radionuclide Chemistry," Sandia National Laboratories, Albuquerque, NM.

15. There are numerous discrepancies in the numbers of shipments and schedules in the report. For example, Table 3-6, page 3-45, shows Alcove 1 with 25 shipments (1,050 drums) and Alcove 2 with 17 shipments (714 drums), while Table 3-5 on page 3-42 shows both Alcoves with 1,100 drums.

16. No justification has been provided for the amounts of waste emplacement proposed for different experiments and for operational demonstration. For example, what is the basis of reducing the experimental waste amounts from 3% in 1988 to 0.75% in 1989 and increasing the Operational Demonstration amounts from 0% in the 1988 proposal to 8% in the 1989 proposal? Similarly, the effect of arbitrarily reducing the first three-year waste emplacement from 4.4% to 3% has not been explained. Do these numbers have any scientific basis?

17. How was the size (100' x 25' x 13') of the alcoves determined? In last year's plan, the waste was proposed to be emplaced in the regular (300'x 33'x 13') rooms. What is the basis for sizing the alcoves to be one-fourth of the room size? Why not one-fifth, one-third, or one-half of the room dimension?

18. Why is Operations Demonstration needed now? Why can't it be done after the decision has been made to dispose of the waste at WIPP?

19. The DOE is not proposing any emplacement of waste at the High-Level Waste Repository in Nevada for a test phase or operations demonstration before compliance with the EPA/NRC Standards. Why is this plan proposed for WIPP ?

20. The plan does not explain why experiments are needed for CH-TRU waste but not for RH-TRU waste.

21. What are the plans for the Alcoves when the experiments are completed?

If you wish to meet to discuss these questions with us, we will be happy to do so.

Sincerely,

Robert H. Neill
Director

RHN:LC:gt

WPCV 21-0

cc: J. E. Bickel, ALO, DOE

7.7 Appendix G - Letter from DOE to EEG, dated July 11, 1989, with responses to questions on the Test Phase Plan (U.S. DOE, 1989a).

Department of Energy
Albuquerque Operations Office
Waste Isolation Pilot Plant Project Office
P. O. Box 3090
Carlsbad, New Mexico 88221

JUL 11 1989

RECEIVED
JUL 13 1989
ENVIRONMENTAL EVALUATION GROUP

Mr. Robert H. Neill, Director
Environmental Evaluation Group
State of New Mexico
7007 Wyoming, N. E., Suite F-2
Albuquerque, NM 87109

Dear Mr. Neill:

The purpose of this letter is to respond to your recent questions and concerns on the "Draft Plan for the WIPP Test Phase: Performance Assessment and Operation Demonstration" (DOE/WIPP 89-011). These concerns were expressed in your letter dated May 15, 1989.

The enclosure to this letter restates your concerns and provides a response to each of these concerns. In all, there are twenty-one concerns and an equal number of responses. If you have further questions on this plan, please contact Tom Lukow of my staff.

Sincerely,

Thomas E. Lukow for

Jack B. Tillman
Project Manager

Enclosure

cc w/enclosure:
C&C File
J. Kenney, EEG

cc w/o enclosure:
R. Kehrman, WID

WIPP:HJD:E89-0137

RESPONSES TO QUESTIONS DATED MAY 15, 1989 FROM THE ENVIRONMENTAL EVALUATION GROUP

Question 1: Are the room-scale and bin-scale gas generation experiments designed to provide data necessary for performing the calculations to show compliance with the EPA Standards 40 CFR 191, or will the data be used only to confirm the predictions?

Response: Data from the bin-scale tests and the alcoves will be used in performance assessment calculations. There is a great deal of uncertainty associated with the assumptions being used to complete the performance assessments. This uncertainty includes gas generation rates, volumes, mechanisms and types and other waste, salt, brine, backfill interaction factors. This uncertainty can be bounded by conservative assumptions. Some of this conservatism, however, may be unnecessary and may lead to the inclusion of engineered changes to the wastes or the facility, that, with sufficient in situ data may be avoided. Consequently, the data from the tests will be used to address this uncertainty in a scientific manner.

Question 2: What is the basis for keeping the results of the preliminary consequence analysis for internal evaluation only (page 2-23)? The entire Performance Assessment portion of the plan is based on the claim that experiments with waste need to be performed to show compliance with 40 CFR 191, Subpart B, yet we are asked to comment on the plan without benefit of the preliminary work that has been done.

Response: As stated in the plan, the preliminary CCDF's are incomplete and are used for scoping purposes and internal evaluation only. These will lead to subsequent calculations and consequence analysis which will become available for external reviews.

The basis for considering gas generation experiments with real waste are documented in the appendices (A2 and A3) of SAND 89-0462 which were the systems analyses for the SEIS.

Question 3: The Sensitivity and Uncertainty Analysis described on pages 2-23 to 2-25 must have been done in order to plan the experiments for performance assessment. Please let us have a copy of the "preliminary sensitivity study (that) identified the human - intrusion scenarios as critical" (page 2-24). This study is also reported (page 2-24) to have identified "gas generation" as one of the four "energy sources...that could move waste from the repository horizon to the accessible environment." The importance and relevance of the proposed in situ gas generation experiments cannot be evaluated without first critically examining the sensitivity study.

Response: The sensitivity study referred to is an internal working study which was the topic of a meeting with the EEG in the fall of 1987. (The attached draft copy is provided for your use and should not be distributed outside of EEG). This study took into account variables such as, brine seepage and waste inventory to see whether these factors warranted further study.

Question 4: The rate of closure of the excavations has been mentioned in several places in the report as a parameter for which more data needs to be obtained in order to proceed with the performance assessment calculations. We know that the rate of closure of the rooms and drifts, with and without heat, has been studied extensively at WIPP for the past six years, and there are a number of technical papers in the open literature on this subject. Even the discrepancy between the predicted and observed rates of closure has been explained by using different models for the mechanical behavior of salt. Why can't the performance assessment proceed without additional study of the room closure rates?

Response: The time dependent performance of salt requires evaluation of closure data over relatively long periods of time. Rock mechanics studies at WIPP presently focus on understanding the development of the disturbed zone surrounding the excavation and the creep characteristics of the salt. Recent changes in the constitutive law for salt have improved our predictive capability and additional data are necessary to validate the new model. Furthermore, it is appropriate to routinely monitor room closure in order to assess performance and ensure safety.

Question 5: The schedule of the proposed experiments, data availability, time needed for completing the performance analysis calculations, and the availability of the results of performance assessment, has not been presented in a consistent manner in the document. Furthermore, the schedule for the events presented in this document is not consistent with other recently published DOE documents. We need your best and most current projection of the sequential schedule of these events in order to comment on the proposed program.

Response: All schedules will be reassessed and clearly defined in the revision to the draft plan. However, the major milestones contained in the Performance Assessment schedule of the Test Plan are expected to remain unchanged.

Question 6: What is the projected schedule for the selection of backfill? What "experimental and performance assessment activities" (page 3-40) are required for this selection to be made and how? What is a "backfill emplacement demonstration" (page 3-40), and when and how will it be carried out? The text suggest that the backfill will not be selected until the backfill emplacement demonstration or the performance assessment is completed.

Response: A backfill recommendation for large-scale evaluation will be made by mid-1991, in time to employ that backfill design in the last two alcove test rooms. The efficacy of various backfill additives to reduce the concerns for gas generated from the waste and for brine inflows will be assessed.

The activity referred to here is the actual emplacement of backfill over the experimental wastes in alcoves 5 and 6. This is not a separate "demonstration" as the text implies. This would not occur until after mock retrieval demonstrations using backfilled waste have been completed.

Question 7: How and when will the "demonstration of seal performance" (page 3-40) be carried out? Will this demonstration include the room, panel, shaft, and borehole seals? Have the designs of the plugs and seals to be used for WIPP been completed? If not, when and how are these decisions to be made?

Response: The "demonstration of seal performance" referenced on page 3-40, relates to sealing the alcove. This section of the test is not discussing panels, shafts and borehole seals for the operations demonstration but rather for emplacing waste for the test program. The effectiveness of the seal will be tested in a newly constructed test-alcove off W30 between N110 and N780 in the August-September time frame.

As described in Section 2.0 of the Plan, the design of the plugs and seals for the rooms, shafts, etc., have not been completed. Section 2.6.2.2 describes the tests to be conducted and Figure 1-7 (page 1-20) shows how seal evaluations can be used to impact the final design.

Question 8: How will the retrievability of the experimental waste be ensured? Are you planning to perform another "mock retrieval demonstration" (page 3-42)? Experimental rooms #1 and #2, that were excavated in March and April 1983, have shown serious and continuous cracks in the ceiling and the walls and have been closed. Cracks in the floors of the experimental rooms were observed in October 1985, only two and one-half years after their excavation. Since these rooms were excavated to the same dimensions as the waste emplacement rooms and in the same stratigraphic horizon, their failure in six years does not provide much confidence in maintaining easy retrievability from the waste rooms for ten years (five years to emplace and five years to retrieve). What would be the disposition of the retrieved waste?

Response: The retrieval of the experimental waste from Panel 1 is being ensured by the inclusion of sufficient clearances between the waste and the salt to allow for creep closure and of a support system for the roof to maintain safe working conditions.

Sufficient clearance for creep is being achieved by:

- o mining rooms to maximum height
- o not using backfill
- o retrimming rooms just prior to waste emplacement
- o working with a reduced ventilation space over the waste.

The ground support system for Storage Rooms 1 through 6 in Panel 1 is shown in Attachment I. It is based on 10 ft. bolts anchored above the anhydrite "b" layer, which is the geologic media in the SPDV Test Rooms experiencing bed separation. The bolting may not prevent bed separation and roof fracturing from occurring but it will provide support for the roof during retrieval operations. A modified bolting system has been used in areas in Panel 1 that will be accessible for routine maintenance. The increased closure rates measured in the SPDV Test Rooms indicate that retrieval should be accomplished within approximately 8 1/2 years following waste emplacement. This provides a minimum period of 3 1/2 years for waste retrieval. Retrieval within this timeframe is readily achievable for the approximately 23,000 drums of waste presently proposed for emplacement during the WIPP Test Phase.

Another mock retrieval demonstration will be required to demonstrate that waste can be retrieved from an alcove that has been backfilled. Interim storage options, should retrieval become necessary are being evaluated. Retrieved waste would be shipped to an interim storage facility pending final disposition.

Question 9: How will the decision be made on engineered modifications and waste treatment, if necessary to meet compliance with the EPA Standards? Would it not be advisable to begin experiments for these purposes now, rather than waiting until after the decision is made to incorporate engineered modifications or waste reprocessing in the design?

Response: The results of performance assessment and, to a lesser degree the sensitivity analyses, will provide information on whether the standard will be satisfied according to the present design and will also indicate which parameter must be better defined or modified by engineered enhancements in order to provide the increase in confidence that the standard will be met. Some experiments are ongoing at the present time in the laboratory to investigate modified backfills.

Question 10: It is stated (page ES-1) that compliance with only Sections 13 and 15 of the EPA Standards, 40 CFR 191, will be demonstrated during the test phase. Why not Sections 14 and 16? In our opinion, compliance with Section 14 (Assurance Requirements) should have been demonstrated by now by developing the design for markers, etc., and by publishing a report to show that the favorable geologic conditions compensate for the presence of natural resources underground at WIPP. The determination that the site did not meet this requirement after the emplacement of 60,500 drums would not make sense.

Response: The implementation of 40 CFR 191.14 is a requirement after the facility is decontaminated and decommissioned. This will occur some thirty years in the future. A decision even to operate the facility in a disposal mode is not scheduled for about five years. The implementation should employ state-of-the-art techniques available in the 2020 A.D. time frame. A great deal of work has already been completed for the Office of Nuclear Waste Isolation (ONWI) regarding marker design and placement. This information is available for WIPP. In fact, ONWI-354 uses WIPP as a type location for markers and proposes a plan for marker design and placement.

Regarding natural resources, the report referenced in EEG's comment is expected to be published during July or August of 1989. Section 40 CFR 191.16 applies only when a special source of groundwater [as defined in 40 CFR 191.12(n)] is present. The WIPP site does not fit into this category, so Section 16 does not apply.

Question 11: Two conflicting layouts of the emplacement of waste during the test phase were presented to us during the DOE presentation of the Plan on April 21, 1989. The layout shown on page 3-41 does not match the layout presented by Martin Molecke, but the references to the test alcove numbers in the text appear to refer to the layout presented by Dr. Molecke at the meeting. What is the officially proposed layout?

Response: The current layout has alcoves 1-4 located immediately opposite and north of Rooms 4-7 in Panel 1. The entryways to each alcove (100' x 25' x 13') will be 170' long, 14' wide x 13' high. Engineering analyses of these layouts are being conducted and will be reported in the latter part of July. Alcoves 5 and 6 are tentatively planned to be excavated in Panel 2.

Question 12: The Waste Emplacement Schedule figure on the "Notice to Reader" page of the document shows a solid horizontal line from September 1992 to September 1994. Does this mean that no additional waste is proposed to be emplaced during that period of two years?

Response: The intent of the figure cited is to indicate that the emplacement schedule for the final two years of the test period will be determined during or following assessment of the first three year period.

Question 13: A draft test plan for WIPP Room-Scale CH-TRU Tests is scheduled to be available on April 1, 1989 (mid-FY 89), as stated on page 2-109. Similarly, a draft test plan for WIPP Bin-Scale CH-TRU Waste Tests is scheduled to be available sometime between October 1, 1988, and October 1, 1989 (FY 89), page 2-112. The three-page description (pages 2-106 to 2-109) of the Room-Scale Gas Generation Tests and a similarly brief description of the Bin-Scale Tests (page 2-110 to 2-112) does not provide "Details on the waste mix compositions, types and quantities of waste drums and backfills, getters, degradation product contaminants, extent of brine moistening, atmosphere control (aerobic/anaerobic, pressures), instrumentation and control hardware, and emplacement schedules..." (pages 2-109 and 2-112). it would not be possible for us to comment on the suitability and the adequacy of your plans for experiments with waste without considerably more details and consistency.

Response: The draft test plans referred to were provided to the EEG at the NAS meeting June 7, 1989 even though they are draft documents presently undergoing internal review and may be modified by on-going reviews.

Question 14: The following reference, cited in Appendix A, is needed to understand the plans for laboratory and modeling studies of repository and radionuclide chemistry. Please make this report available as soon as possible.

Brush, L.H., 1989, (in preparation). "Test Plan for Laboratory and Modeling Studies of Repository and Radionuclide Chemistry," Sandia National Laboratories, Albuquerque, NM.

Response: The test plan will be provided to EEG as soon as it is completed by the author and reviewed by management. It is anticipated that the plan will become available in October 1989.

Question 15: There are numerous discrepancies in the numbers of shipments and schedules in the report. For example, Table 3-6, page 3-45, shows Alcove 1 with 25 shipments (1,050 drums) and Alcove 2 with 17 shipments (714 drums), while page 3-5 on page 3-42 shows Alcoves with 1,100 drums.

Response: This draft plan does contain discrepancies in the figures noted. During planned revisions, updated information will be assured.

Question 16: No justification has been provided for the amounts of waste emplacement proposed for different experiments and for operational demonstration. For example, what is the basis of reducing the experimental waste amounts from 3% in 1988 to 0.75% in 1989 and increasing the Operational Demonstration amounts from 0% in the 1988 proposal to 8% in the 1989 proposal? Similarly, the effect of arbitrarily reducing the first three-year waste emplacement from 4.4% to 3% has not been explained. Do these numbers have any scientific basis?

Response: Operations Demonstration waste receipt ramp-up has been constructed to check the various operational parameters of the waste receipt process. As designed, the system will provide the opportunity for evaluating the generator sites, transportation system, TRUPACT II efficacy. and the WIPP facility.

Question 17: How was the size (100'x 25'x13') of the alcoves determined? In last year's plan, the waste was proposed to be emplaced in the regular (300'x33'x13') rooms. What is the basis for sizing the alcoves to be one-fourth of the room size? Why not one-fifth, one-third, or one-half of the room dimension?

Response: The dimensions of the test alcoves (100'x25'x13') are based on the number of drums needed for the test and the desire to keep a minimum width to provide a more stable back. The alcove was sized to keep the volume small to facilitate the measurements of gas during the test. In addition to having a smaller width, the back in the test rooms will be rock bolted to ensure safe retrieval of the test drums at the end of the test.

Question 18: Why is Operations Demonstration needed now? Why can't it be done after the decision has been made to dispose of the waste at WIPP?

Response: A full WIPP Operations Demonstration at the earliest possible time will provide a unique opportunity to identify and implement design and programmatic changes that increase the reliability and efficiency of the waste receipt process. In addition, the decision on full scale repository operations will benefit from the results of the operations demonstration as well as completion of the Performance Assessment.

Question 19: The DOE is not proposing any emplacement of waste at the High-Level Waste Repository in Nevada for a test phase or operations demonstration before compliance with the EPA/NRC Standards. Why is this plan proposed for WIPP?

Response: DOE is fully complying with the EPA standards in its approach in opening the WIPP facility. There is no regulatory requirement to demonstrate compliance prior to bringing wastes to WIPP. This has been stated on repeated occasions by the EPA.

The waste destined for the High-Level Waste repository in Nevada will be in a very different waste form than the TRU-wastes destined for WIPP. Since the TRU-wastes consist of a wide variety of heterogeneous wastes, a test phase with actual waste is warranted.

Question 20: The plan does not explain why experiments are needed for CH-TRU waste but not for RH-TRU waste.

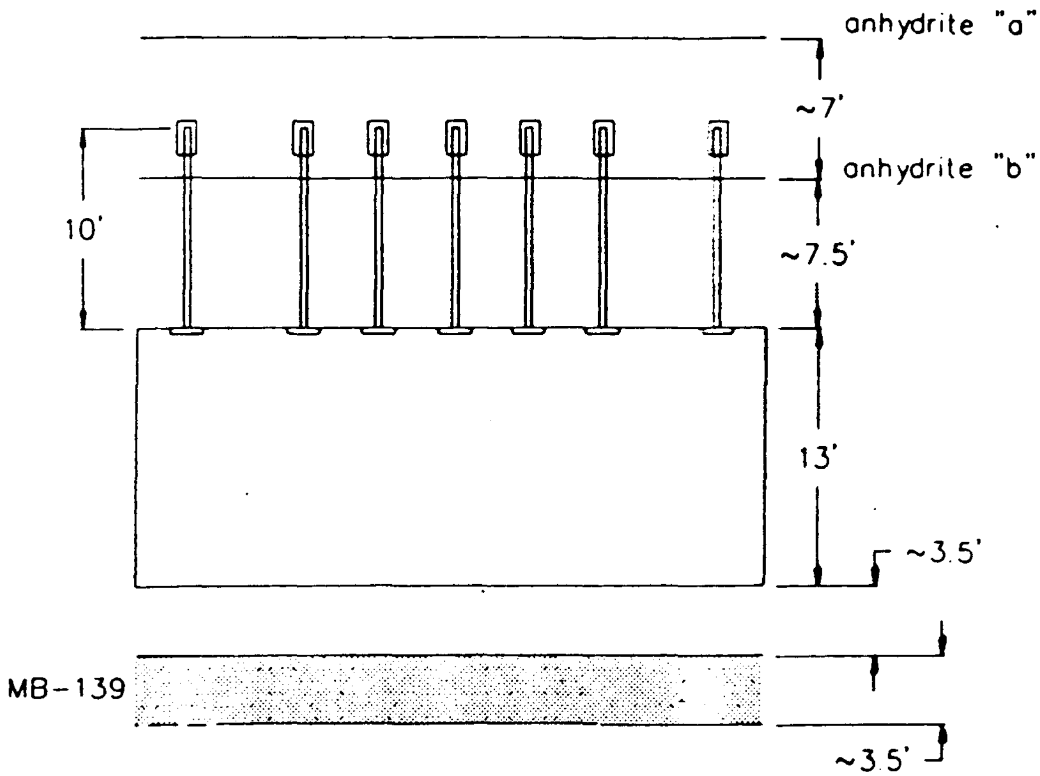
Response: The RH-TRU is a very small (3%) fraction of the total waste inventory and, should not significantly contribute to the gas generation concern. In addition, emplacement of RH-TRU wastes in an easily retrievable made would not permit experiments which address radioactivity and the low doses to the surrounding salt would not require such evaluations.

Question 21: What are the plans for the Alcoves when the experiments are completed?

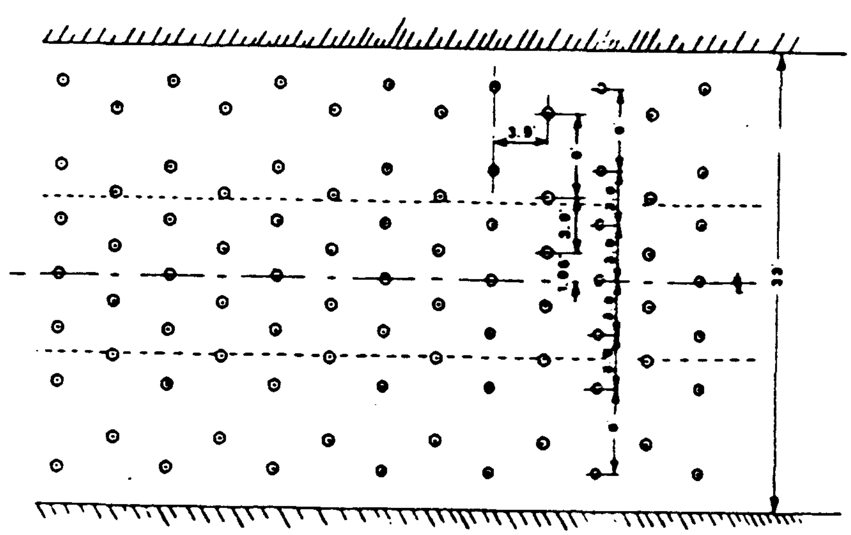
Response: When experiments are completed in the alcoves, the waste will be removed and the alcoves backfilled.

ATTACHMENT I

GENERALIZED STRATIGRAPHY AROUND STORAGE ROOMS SHOWING ROCKBOLT LOCATIONS



PANEL 1 ROOMS 1–6 BOLT PATTERN



⊙ 3/4" DIAMETER, MECHANICAL ROCK BOLT, 10' IN LENGTH
BOLT TORQUE - 150 FT-LBS TO 100 FT-LBS

7.8 Appendix H - Letter from EEG to Senator Domenici, dated July 9, 1989, providing interim assessment of U.S. DOE (1989a).

ENVIRONMENTAL EVALUATION GROUP

AN EQUAL OPPORTUNITY / AFFIRMATIVE ACTION EMPLOYER

7007 WYOMING BOULEVARD, N.E.
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ALBUQUERQUE, NEW MEXICO 87109
(505) 828-1003

July 9, 1989

The Honorable Pete Domenici
United States Senate
434 Dirksen Building
Washington, DC 20510

Dear Senator Domenici:

Your letters of May 9, 1989 and June 23, 1989 requested EEG's evaluation of the technical merits of the DOE proposed experiments and operational demonstration (Ref. 1) using transuranic waste at WIPP prior to the demonstration of compliance with Subpart B of the EPA Standards for safe disposal of high level and transuranic waste (Ref. 2). The following is intended to keep you posted on the status of our analyses to date.

<u>Availability of Information</u>
Unfortunately, DOE has not yet provided the information requested in my letters of May 15 and June 19, 1989 (Ref. 3 and 4) to enable us to fully evaluate the merits of the proposed experiments.

The Draft Plan, received on April 26, 1989, is incomplete, lacking in details, and inconsistent with the additional information provided by DOE in an Addendum to the Draft Plan on June 6, 1989 and in Preliminary Test Plans on June 7, 1989 for the bin and alcove experiments (Ref. 5 and 6).

<u>Experiments for Performance Assessment</u>
DOE is proposing experiments with 4,500 drums of TRU waste in WIPP to be emplaced over a 3.5 year period, primarily to study the rate of gas production. Projections of conditions in the repository for the first 10,000 years after emplacement indicate potential problems in demonstrating compliance with human intrusion scenarios in Subpart B of the EPA Standards for TRU Waste Disposal (Ref. 2). We concur with DOE that it would be a good idea to have better estimates of gases to be produced by the waste, so that the assessment of compliance with the EPA Standards can be based on more reliable data on gas generation than is currently available. However, experiments and analyses to address and <u>solve</u> problems caused by gas generation are probably of equal or even greater importance and are not being proposed. This

would include work on the prevention of gas generation by waste treatment as well as elimination of gases after production.

It should be noted that the results of the experiments will not assure compliance with the Standards, nor do the Standards require, in an obligatory sense, any experimentation with waste.

While DOE has not identified any additional scientific experimentation that could provide a better understanding of the future behavior of the repository, scientific experimentation should not be confined to only those studies in direct support of performance assessment. Nonetheless, the total amount of CH-TRU waste that has been identified by DOE for experiments in support of performance assessment is 4,500 drums, and that should be regarded as an upper limit. It amounts to approximately 0.6% of the 5,600,000 cubic feet of CH-TRU waste expected to be generated and shipped to WIPP.

Bin-Scale Experiments

Of the 4,500 experimental drums of CH-TRU waste, 650 drums are for the "Bin-Scale" experiments. Although we have not been able to evaluate the individual bin experiments being proposed, there is much useful information that can be obtained and we believe the bin experiments should be started as quickly as possible. EPA estimates that the earliest date for approval of DOE's request for a variance to their no-migration petition for mixed wastes will be March 1990. This means that underground emplacement of bins that require mixed waste in order to obtain a representative mixture of the various CH-TRU waste forms for gas generation experiments cannot begin until that time unless DOE requests and receives an exemption from EPA to emplace RCRA waste in WIPP for scientific experimentation prior to receiving a variance from that agency. Hence, consideration should be given to conducting those tests requiring mixed waste elsewhere, because it may be almost a year before representative shipments of the different waste forms to WIPP can begin.

Alcove-Scale Experiments

Different transuranic waste forms totaling 3,850 drums with additives simulating repository conditions would be emplaced in five alcoves underground at WIPP. Conflicting schedules of the amount of time to emplace waste and then seal each alcove range from four to nine months in the various documents, making it fruitless to determine the expected availability of gas data to be used in the demonstration of compliance with the EPA Standards (Performance Assessment) scheduled for draft publication in September 1992. We will need to perform a more detailed evaluation of the proposed experiments in order to determine their value.

Operational Demonstration

DOE proposes to ship 18,300 drums for operational demonstration during a three-year period and would reserve the option to emplace as many as 63,500 drums for operational demonstration (68,000 total drum-equivalents minus 4,500 drum-equivalents for scientific experimentation) before meeting the Standards. We do not believe that waste should be brought to WIPP for this purpose prior to proving that the facility can meet the Standards for safe disposal for the following reasons:

1. There is little technical knowledge or experience to be gained in conducting waste handling activities at WIPP before completing a number of required actions. Waste certification is occurring at the generating sites, as is packaging and waste handling. DOE has transported more than 100,000 CH-TRU waste drums from the generating sites to INEL since 1970 and is still transporting drums today.

2. The emplacement of 18,300 drums before making a decision on the need to process wastes (e.g., cementation, crushing, incineration, etc.) could result in needless transportation and operations related occupational radiation exposure. If treatment is required, a facility would have to be built for this purpose at WIPP, or waste would have to be transported back to Rocky Flats or elsewhere for processing.

3. Until DOE commits to the actual waste emplacement conditions including backfill, getters, or other engineering modifications, waste emplacement will not represent actual conditions. And those commitments will be heavily based on the results of the performance assessment.

4. Operational demonstration is unrelated to the demonstration of compliance with the disposal requirements of the EPA Standards.

5. If the scientific experiments with 4,500 drums are conducted, it will require 107 truck shipments. Unloading more than 300 TRUPACTs and moving the material through the system will provide considerable operational experience.

6. It is important to demonstrate an ability to emplace increasing amounts of waste safely, but we see no purpose to doing it twice, now and when the

disposal phase begins.

7. DOE has not identified any need to conduct operational demonstrations at the HLW facility in Nevada and has no plans to do so prior to demonstrating compliance with the EPA and NRC Standards for disposal. Experiments and operational demonstration with HLW at the Climax Mine in Nevada involved a dozen shipments, which is insignificant compared to the 1,500 planned shipments to WIPP for operational demonstration.

Remote Handled Transuranic (RH-TRU) Wastes

Since no experiments with Remote Handled Transuranic (RH-TRU) wastes have been identified, there is no need to ship these wastes before the decision to proceed with WIPP as a disposal facility is made.

Compliance with the EPA Standards

Efforts to assess WIPP's compliance with the EPA Standards should be accelerated so that a decision on the use of WIPP as a disposal facility may be made without undue delay. Little progress has been reported in probabilistic risk performance assessment towards the draft publication target date of September 1992 since the Standards were promulgated in September 1985.

Our evaluation of the alcove experiments will be provided as soon as DOE responds to our requests.

Sincerely,

Robert H. Neill
Director

RHN:gt

REFERENCES

1. Draft Plan for WIPP Test Phase: Performance Assessment and Operations Demonstration, April 1989, DOE/WIPP 89-011.

2. Environmental Radiation Protection Standards for Management and Disposal of Spent Nuclear Fuel, High-Level and Transuranic Radioactive Wastes, 40 CFR 191, U.S. Environmental Protection Agency, September 1985.

3. May 15, 1989 letter from Robert H. Neill, Director EEG, to Jack B. Tillman, Project Manager, WIPP Project Office.

4. June 19, 1989 letter from Robert H. Neill, Director EEG, to Jack B. Tillman, Project Manager, WIPP Project Office.

5. Draft Test Plan: WIPP Bin-Scale CH-TRU Waste Tests, Martin Molecke, Sandia National Laboratories, May 1989.

6. Draft Test Plan: WIPP *In Situ* Room-Scale CH-TRU Waste Tests, Martin Molecke, Sandia National Laboratories, June 1989.