CONF-800527--3

SAND80-0502C

ROLE OF BOREHOLE PLUGGING IN THE EVALUATION OF THE WASTE ISOLATION PILOT PLANT*

T. O. Hunter
Sandia National Laboratories
Albuquerque, New Mexico 87185

ABSTRACT

Research on borehole plugging (BHP) is part of an integrated strategy to develop technology that can assure successful nuclear waste isolation. The application of this strategy to the Waste Isolation Pilot Plant (WIPP) in southeastern New Mexico has included an assessment of the role BHP plays in the development of a repository at that site. This paper presents a description of the WIPP site, repository design, and the current research and development program. The status of drill holes--those drilled for petroleum and potash exploration and those drilled for site characterization--within the proposed site boundaries is presented. Sixty-six holes are present on the 7700 hectare (19,000 acre) site, yet only 8 penetrate as deep as the proposed repository location. The assumptions made about shaft and borehole sealing in consequence assessment studies are presented. The results of these studies indicate that borehole seals with effective permeabilities greater than tens of darcies would result in doses to maximally exposed individuals of less than 0.01% of natural background.

Presented at
Workshop on Borehole and Shaft Plugging
Columbus, Ohio
May 7-9, 1980

*This work is supported by the U. S. Department of Energy.

DISCLAIMER

SAND80-0502C

ROLE OF BOREHOLE PLUGGING IN THE EVALUATION OF THE WASTE ISOLATION PILOT PLANT*

T. O. Hunter
Experimental Programs Division
Sandia National Laboratories
Albuquerque, New Mexico 87185

INTRODUCTION

The U.S. Department of Energy (DOE) proposed the development of a repository for disposal of nuclear waste from the defense programs at a site in New Mexico. This project, called the Waste Isolation Pilot Plant (WIPP), has a twofold mission: a pilot repository for retrievable storage of defense transuranic (TRU) wastes, and a facility for experimentation on the interaction of defense high-level wastes and bedded salt.(1) Current recommendations by the DOE include the termination of project activities which support the unlicensed disposal of TRU wastes and research and development on defense waste.(2) The site in southeastern New Mexico would continue to be evaluated along with other sites in the United States for potential consideration as a licensed repository for both defense and commercial high-level wastes.

SITE AND REPOSITORY DESCRIPTION

Studies relating to the design, operation, and safety assessment of the proposed WIPP repository are based on assumptions about the characteristics of the waste to be received there. The long-term (post-operation) assessments that were performed are based on TRU wastes, whose general characteristics were conservatively presumed to be those presented in Table I.(1) These wastes are primarily contact-handled and produce insignificant quantities of heat and penetrating radiation. A detailed study of the potential interaction between these wastes and the environment imposed by the WIPP repository has been performed for development of waste acceptance criteria.(3)

TABLE I
WIPP WASTE FORMS
(Transuranic Wastes)

- o TRU Content $>$ 10 NCi/gm

CONTACT HANDLED

- o 210-liter drum $<$ 5-10 gm Pu
- o 0.04 Watt/drum
- o Surface Dose Rate (SDR) 200 mrem/hr

REMOTE HANDLED

- o 200 mrem/hr $<$ SDR $<$ 100 rem/hr
- o 4 watts/(0.6 x 4.6 m can) (2 x 15 ft can)

Site Characterization

Geologic and hydrologic investigations have been in progress in southeastern New Mexico since 1972. The site presently under investigation is called the "Los Medanos" site and is located in the Delaware Basin, which is one of a series of sedimentary basins within the Permian Basin that extends into Texas, Oklahoma, Colorado, and Kansas. The general location of the WIPP site is shown in Figure 1. Extensive geologic and hydrologic investigations have resulted in a detailed characterization of the site under consideration.(4)

The stratigraphy at the site is illustrated by the cross-section shown in Figure 2. The intervals of particular interest in the evaluation of the consequences of radionuclide release and consequently the integrity of

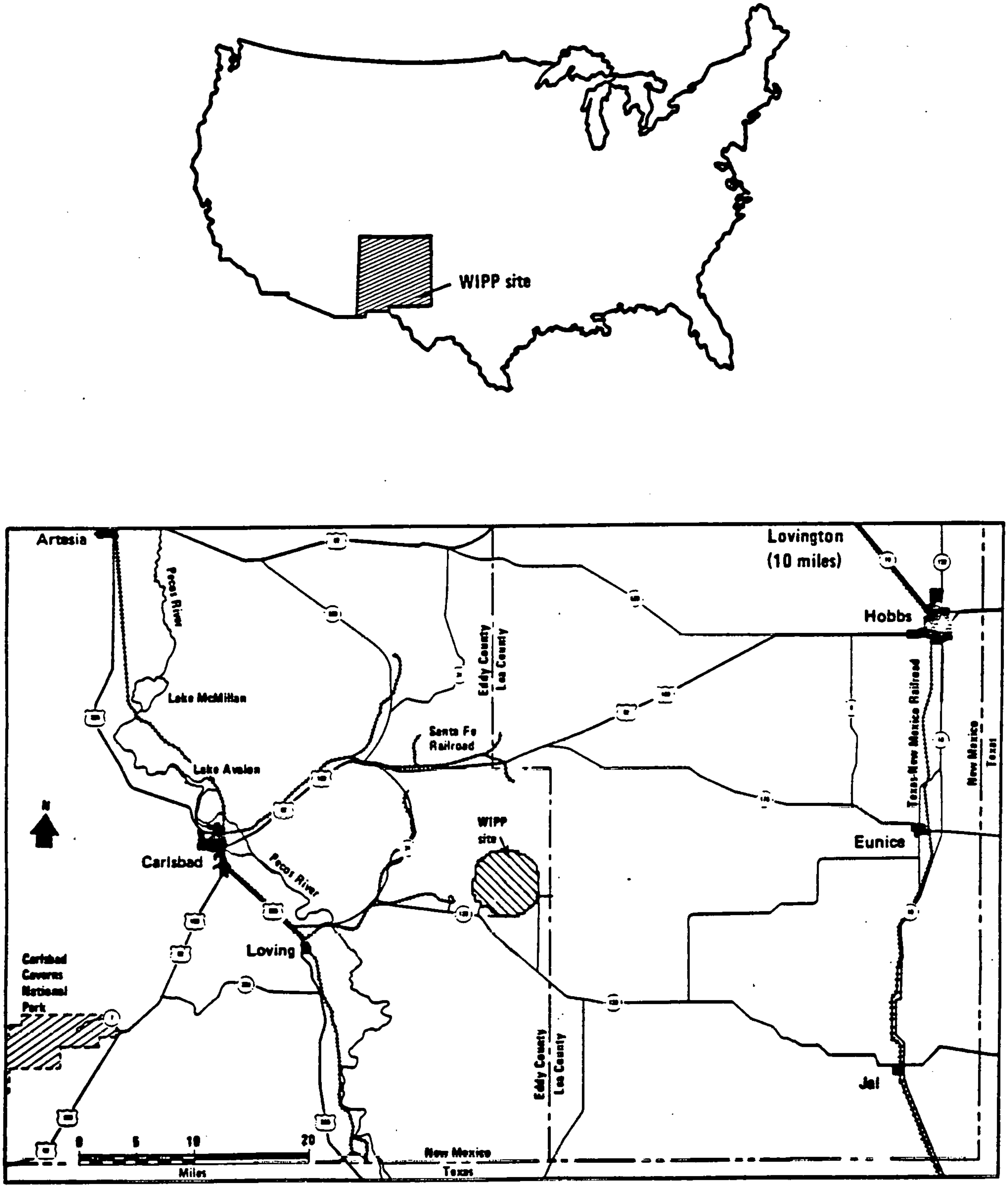

Figure 1. GENERAL LOCATION OF WIPP SITE

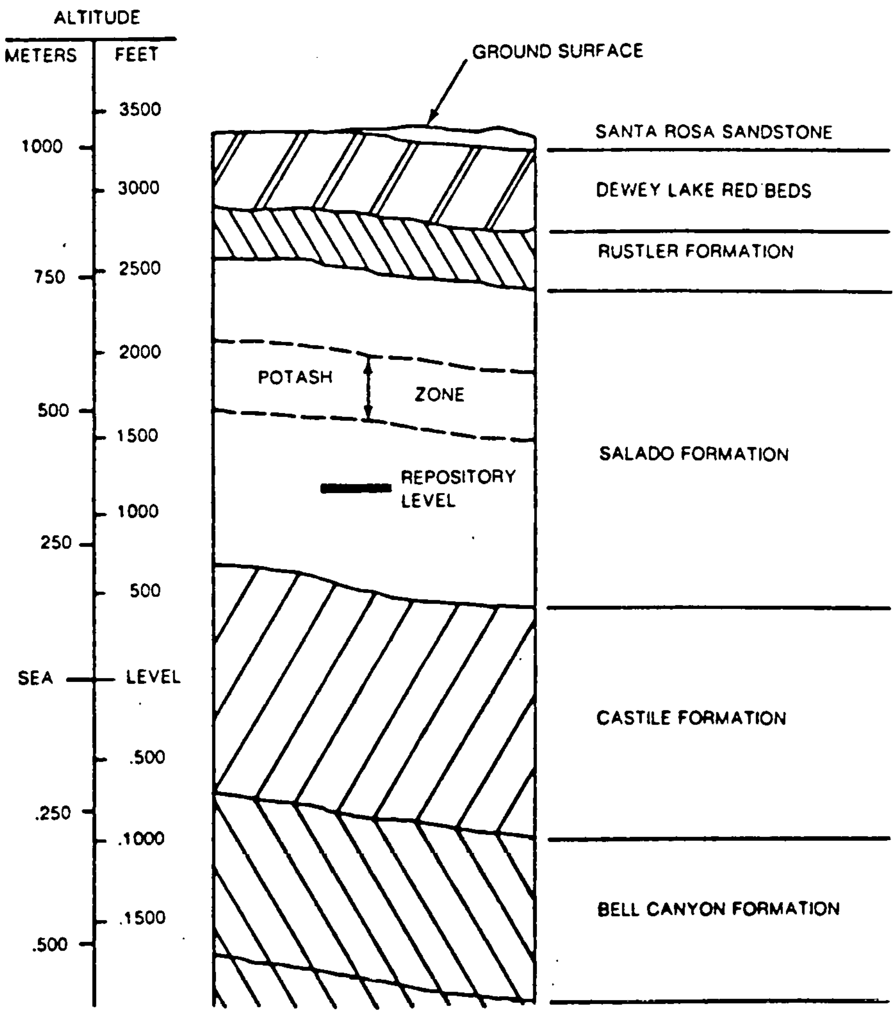

Figure 2. STRATIGRAPHY AT WIPP SITE

penetrations are: (a) Rustler Formation, which, at the center of the site, extends from 168 m (550 ft) to 247 m (810 ft) below the surface; (b) the Salado, which extends from the Rustler to about 850 m (2800 ft) below the surface and (c) the Delaware Mountain Group, which is about 1220 m (4000 ft) thick with its top at about 1220 m (4000 ft) below the surface.

The Rustler is primarily anhydrite and siltstone, but does contain two dolomite beds--the Culebra and Magenta, the most significant aquifers in the area--each of which are about 7.6 m, (25 ft) thick at depths of about 220 m and 186 m (720 and 610 ft), respectively. The Culebra and Magenta are considered confined aquifers with an average porosity of about 10% and a calculated transmissivity ranging from 10^{-10} to 1.5×10^{-4} m^2/s (10^{-4} to 140 ft^2/day), depending on the locality and degree of fracturing. The total dissolved solids range from 3000 to 60,000 ppm.(4) The Salado Formation contains the location of the proposed repository horizon (660 m, 2160 ft) within its lower member. At the repository location, the Salado is primarily halite but also has thin beds of anhydrite and polyhalite. Thin clay zones are also present. The Salado does not contain circulating groundwater.

The Delaware Mountain Group consists primarily of sandstone, limestone, and shale and has been characterized as having an average porosity of 10% and an average conductivity of 7×10^{-8} m/s (0.02 ft/day). The upper formation in this group is the Bell Canyon Formation. Groundwater yields from wells in Bell Canyon Formation are approximately 3.8×10^{-5} to 9.5×10^{-5} m^3/s (0.6 to 1.5 gal/minute).(4)

Repository Design

The proposed repository for defense wastes at the WIPP site is depicted in Figure 3. It consists of a single-level excavation using conventional room and pillar mining techniques. Surface facilities used during operation include a waste handling building, an underground personnel building for support of underground operations, a storage-exhaust-filtration building, an administration building, and various support buildings. The subsurface development includes four shafts to the underground, storage rooms for TRU wastes, and areas for experiments.(5)

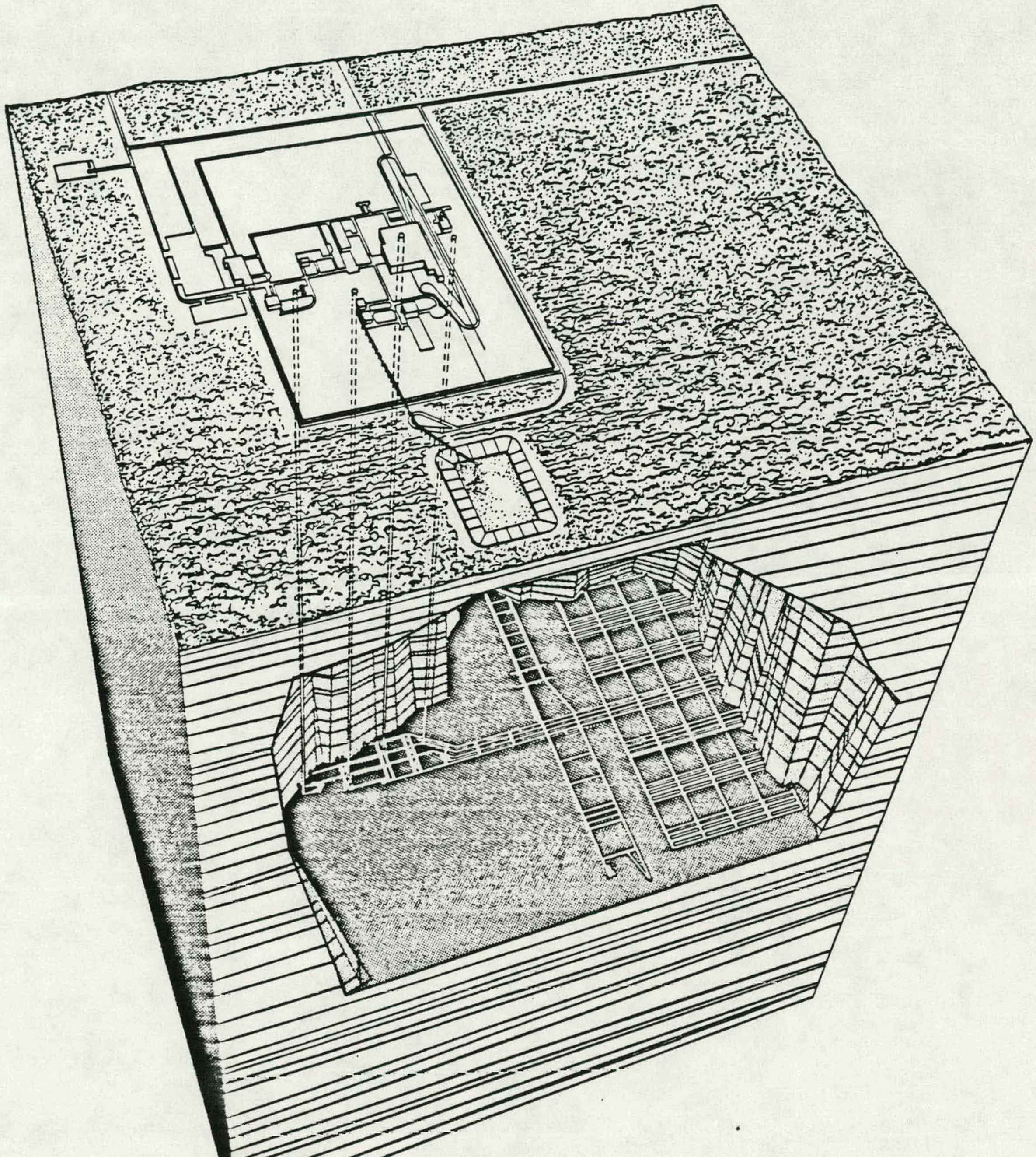

Figure 3. THE PROPOSED WIPP REPOSITORY

EXPERIMENTAL PROGRAM

The development of the WIPP has been supported by an experimental program that addresses the technical concerns identified in the design and safety assessment of the facility. This program includes eight program areas that are oriented towards specific issues.(6) A brief description of these areas follows:

Tru Waste Characterization Studies--Studies of the interaction of transuranic wastes with the salt environment, including assessment of potential degradation mechanisms and the impact on the repository and radionuclide isolation.

High-level Waste Interaction--Studies of the interaction of thermal and radiation fields from heat-producing wastes with the salt environment and the impact on the waste form encapsulating materials.

Thermal-Structural Interaction--Development and verification of methods to evaluate the response of the host rock to both the ambient conditions upon excavation and the enhanced deformation anticipated with heat-producing waste forms.

Permeability--The characterization of the properties of the host rock for permeation of gases or liquids.

Brine Migration--Assessment of the potential for mobilization of natural fluids in the salt and the subsequent interaction with waste containers.

Borehole Plugging--Quantification of the technology for sealing man-made penetrations into or near the storage horizons.

Nuclide Migration--Characterization of the potential for radionuclide migration in the WIPP environment.

Operation and Design--The demonstration and certification of safe operational techniques and appropriate design assumptions.

Each of these areas is being methodically evaluated to accumulate additional data and to correlate all available knowledge into an assessment of the potential consequences to the integrity of the waste isolation mechanism.

Each area may consist of several development phases:

Modeling:	Analytical formulations that can represent or predict phenomena of interest
Laboratory Analyses:	Specific laboratory investigations to develop important parameters and accumulate relevant data

Bench Scale	Intermediate-scale investigations employing larger samples than typically encountered in a laboratory scale
In Situ Testing	Non-radioactive experiments and demonstrations performed in undergound salt environments that can incorporate in situ parameters
WIPP	*The collection of requirements from each program area into a description of and comprehensive plan for experiments to be performed in the portion of the WIPP facility devoted to that purpose*

Borehole Plugging (BHP) is only one component in the development program. The overall assessment of the integrity of the waste isolation system requires the integration of each of these components. The appropriate role of BHP is best evaluated by considering the relative influence of it and other factors, e.g., characterization of the waste stored, interactions with the host rock, response of rocks to repository development and post-operational effects, migration of radionuclides in the local and regional geosphere, in providing acceptable containment and isolation of wastes.

The generic nature of the BHP program has resulted in a cooperative effort between the WIPP program and the Office of Nuclear Waste Isoation (ONWI). This cooperative effort will allow transfer of technology to repository development at other sites.

Subsequent sections will discuss the status of penetrations at and near the WIPP site and the assumptions that have been made in the safety assessments about plugging of these penetrations.

PENETRATIONS ASSOCIATED WITH WIPP

Siting studies for a nuclear waste repository must consider the location of existing drill holes within regions under evaluation. Sites for salt repositories such as WIPP are very likely to be located in regions that have been subject to exploratory drilling for hydrocarbons or minerals such as potash ore. The identification of those existing holes is essential in the characterization of a repository site.

In addition, site investigation will require the drilling of numerous holes to evaluate geologic and hydrologic characteristics or to further assess the potential for valuable minerals.

The WIPP site has been divided into four zones that will be controlled by the Department of Energy. Zone I consists of about 40 hectares (100 acres) and will contain most of the surface facilities. Zone II, an area of about 730 hectares (1800 acres), overlies the maximum extent of the underground development. Zone III, with a diameter of approximately 6.4 km (4 miles) and an area of 2500 hectares (6200 acres), is the area in which drilling and mining will be precluded unless further evaluation indicates it is acceptable. Zone IV, with a diameter of 10 km (6 miles) and an area of 4400 hectares (11,000 acres), would allow continuous or drill-and-blast mining under DOE restrictions, but no solution mining. Existing wells in Zone IV would also require sealing by DOE-prescribed methods, and new wells would be drilled and sealed in conformance with DOE standards.

Boreholes

The most credible threat to the WIPP repository imposed by boreholes is communication with deep aquifers. The criteria used in the identification of the current site included the avoidance of land within one mile of any boring into the Delaware Mountain Group or deeper formations.(4) Consequently, the current site does not include any deep holes within one mile of Zones I or II.

Site characterization activities for WIPP in southeastern New Mexico have included the drilling of 71 holes in the general vicinity of the site. Figure 4 shows the location of those exploratory drill holes and the existing industry holes that are within a 260 km^2 (100 mi^2) region surrounding the 4 zones that comprise the site.

The drill holes within the site, both existing industry and DOE exploration, can be generally categorized by such functions as: (1) stratigraphic, (2) hydrologic, (3) potash exploration, and (4) hydrocarbon exploration. A total of 66 holes are present within Zones I, II, III, and IV. Forty-five were drilled by DOE, while 21 were present when site investigation activities began. These drill holes are categorized by function and zone in Table II.

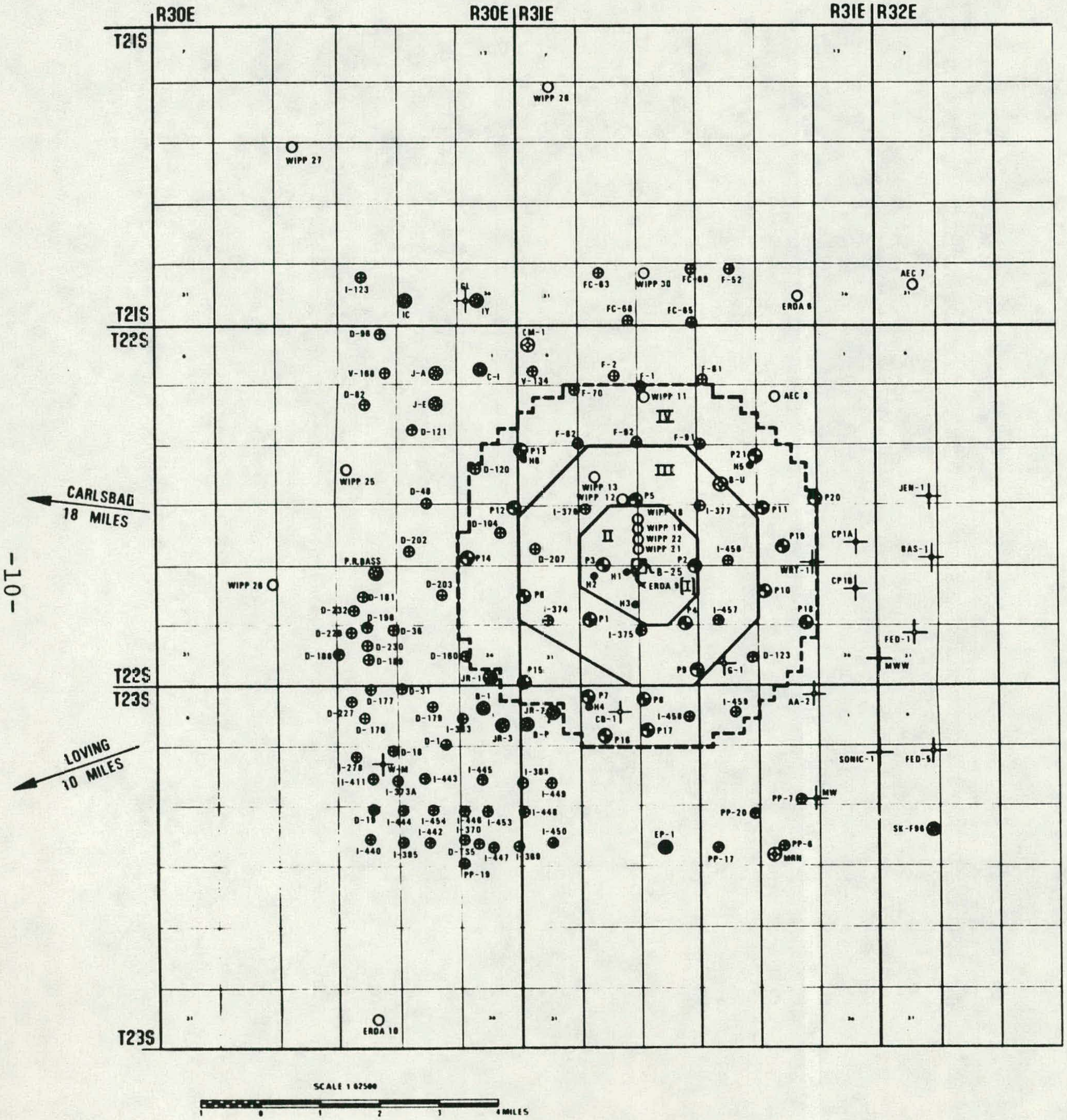

Figure 4

IMMEDIATE AREA
WIPP SITE DRILL HOLE STATUS

Sandia Laboratories

SEPTEMBER 1978

--- LEGEND ---

- -DEEP PRODUCING GAS
- -ABANDONED WELL
- -DEEP & ABANDONED
- -POTASH DRILL HOLES
- -GEOLOGICAL HOLES
- -HYDROLOGICAL HOLES
- -ERDA POTASH DRILL HOLES
- -LAND WITHDRAWAL BOUNDRY

V-U.S. POTASH CO. (MISSISSIPPI POTASH)
D-DTS DUVAL CORP.
I-INTERNATIONAL MINERALS
PP-PERMIAN POTASH
F OR FC-KERR MCGEE

--- NOTES ---

1. ONLY THOSE HOLES WITHIN A 5 MILE GRID NORTH AND SOUTH AND EAST AND WEST OF ERDA 9 ARE SHOWN WITH THE EXCEPTION OF THE ERDA/WIPP SPONSORED HOLES INDICATED.
2. DRILL HOLES NOT SHOWN TO SCALE.

TABLE II

CATEGORIZATION OF DRILL HOLES WITHIN THE WIPP SITE

	STRATIGRAPHIC	HYDROLOGIC	POTASH	HYDROCARBON
ZONE I	1 (DOE)			
ZONE II	4 (DOE)	5 (DOE)	2 (DOE)	
ZONE III	2 (DOE)		5 (DOE) 7 (IND)	
ZONE IV	3 (DOE)	9 (DOE)	14 (DOE) 10 (IND)	4 (IND)

None of the holes in Zones I or II, shown in Table II, extend to the Delaware Mountain Group (DMG). The deepest (ERDA-9) is 880 m (2886 ft) deep, which just penetrates into the Castile Formation (861 m, 2825 ft), and stops 360 m (1200 ft) from the Castile/DMG contact. The holes listed in Table II are displayed in Figure 5 as a function of depth and distance from the center of the site. The only deep holes in Zone III are WIPP-12 and WIPP-13, stratigraphic holes drilled by DOE near the northern perimeter of Zone II and midway between the boundaries of Zones II and III, respectively. An oil exploration hole (BWU-1) that penetrates 4600 m (15,000 ft) is the deepest hole on the site and is located near the inner perimeter of Zone IV approximately 1 mile from Zone II. In all 4 zones, only 8 holes penetrate as deep as the proposed repository horizon and none of the remaining 58 extend closer than several hundred feet of that level. The emphasis of the borehole plugging program at the WIPP site is thus concentrated on those holes that extend to or through the repository level, since no mechanism is envisioned by which fluids can reach the repository from holes that are terminated above the repository. Density stratification in a terminated hole will not allow continued dissolution and, moreover, hole closure in salt will ultimately seal the penetration.

Shafts

The design for the WIPP repository includes 4 shafts. Each extends to the repository level (665 m, 2150 ft) and is lined from the surface to the

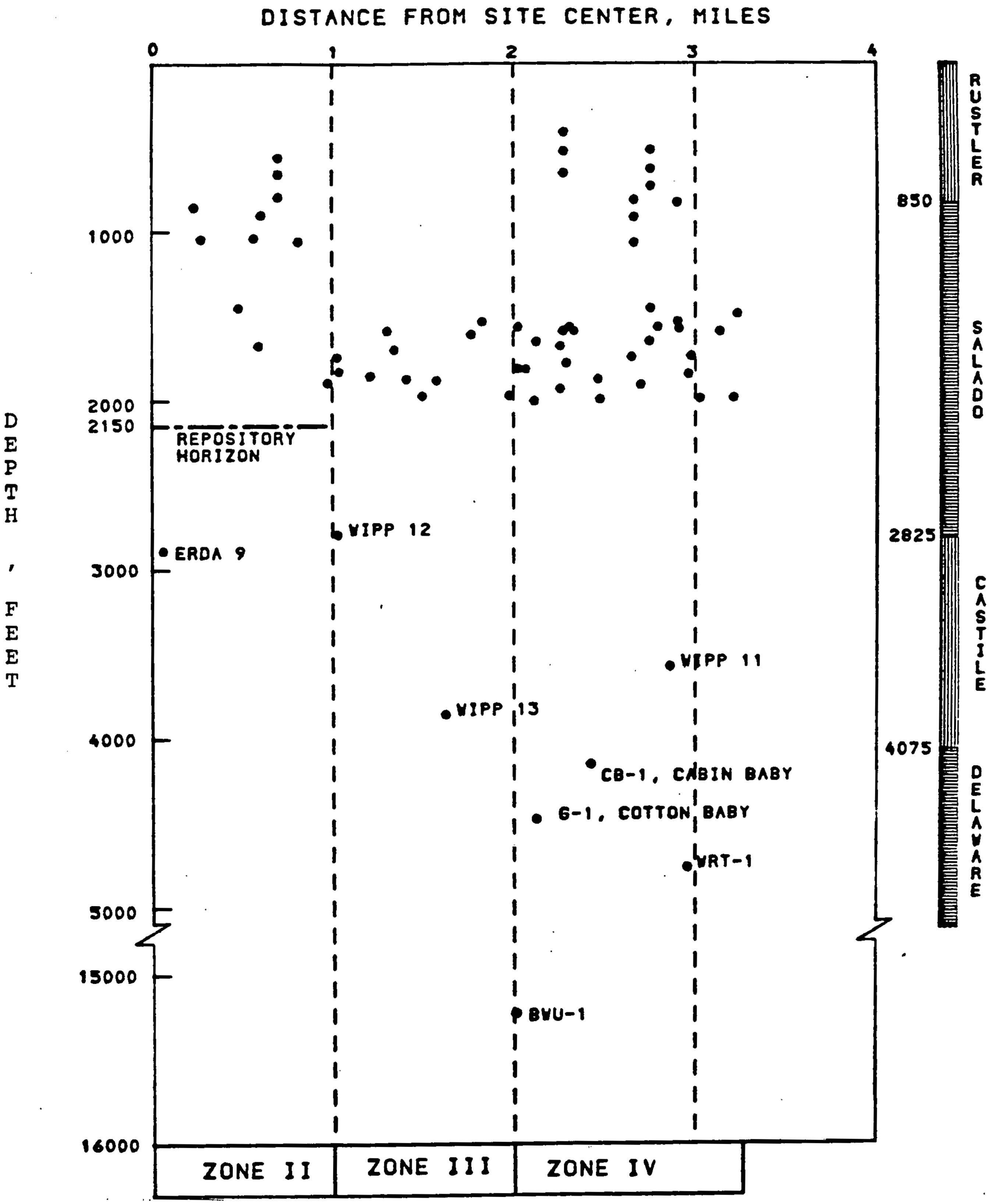

Figure 5. DEPTH OF DRILL HOLES AT WIPP SITE

top of the salt (about 260 m, 850 ft) but unlined thereafter. These shafts are described as follows:(5)

Waste Shaft - 5.8 m (19 ft) in diameter, for transporting of waste

Ventilation Supply and Service Shaft - 4.9 m (16 ft) in diameter, for transporting personnel, materials, and equipment, and for primary air intake

Construction Exhaust and Salt Handling Shaft - 4.3 m (14 ft) in diameter, for salt removal and exhaust air duct for underground construction areas

Storage Exhaust Shaft - 3m (10 ft) in diameter, the exhaust air duct for underground waste storage areas

Site validation activities at the WIPP included plans for early development of two shafts for underground site validation and in situ experimentation.(7) These two shafts would ultimately be converted into the storage exhaust shaft and the waste shaft upon full construction of the repository. The latter shaft would be initially bored at 1.8 m (6 ft) diameter and subsequently expanded to full size. All shafts would be completely plugged upon cessation of operations. One of the shafts would also be coincident with the drill hole (ERDA-9) that currently penetrates through the Salado Formation, thus eliminating concern over two penetrations at that location.

CONSEQUENCE ASSESSMENTS

Determination of the potential hazard from disposal of nuclear waste is addressed by considering various scenarios in which the primary isolation mechanism—the media immediately surrounding the repository--is assumed to be breached. A series of these scenarios have been identified for WIPP.(8)

Consequences of the radionuclide release in these scenarios have been determined and published.(1,5,9) Four of these scenarios are:

1. An open borehole that penetrated the repository allowing fluid transmission between lower and upper aquifers.
2. Two interconnected penetrations of overlying formations that allow fluids to enter the repository at one location and escape into the upper aquifer at another.
3. Diffusion of radionuclides from a flooded repository into overlying aquifers.

4. A direct access scenario in which a drilling operation intercepts a high concentration of radionuclides, thereby exposing the drill crew.

The first three of these scenarios are referred to as liquid breach and transport scenarios and can be examined to determine the role played by borehole plugging.

Consequence assessments are made in terms of the potential dose to an exposed individual in the nearby biosphere. Scenarios are analyzed by first specifying (a) the breaching event, (b) mechanisms for transport out of the repository, (c) the time of breach, and (d) the response of the buried medium to the releasing event. Secondly, the source term in terms of radionuclide inventory and physical and chemical condition of the waste at the time of breach must be determined. Thirdly, geosphere transport calculations are performed to determine the rate of radionuclide transport to the biosphere. In the WIPP analyses, the Rustler aquifers are assumed to be the link to the biosphere. Radionuclides are assumed to move from the repository through the Magenta and Culebra aquifers and to discharge into the Pecos River at Malaga Bend, a point 22 kilometers from the site. Finally, analyses are performed to determine the dose to invididuals who live near the assumed discharge point. These calculations translate the mass fraction of radionuclides in the aquifer water into whole body or specific organ doses considering ingestion, swimming, boating, food consumption, occupancy, and other pathways.

The three liquid breach and transport scenarios are depicted in Figures 6, 7, and 8. A brief description follows:

Scenario 1: A 9-inch uncased borehole allows up to 2.3 m^3/day (600 ft^3/day) of unsaturated brine (230,000 ppm) to enter the repository from the Bell Canyon, dissolve the salt and waste in the repository, and enter the overlying Rustler aquifer as a saturated brine (410,000 ppm). Under these assumptions, the hydraulic resistance of the wellbore as calculated using the Hagen-Poiseville law for laminar flow is negligible compared to the resistance of the aquifers. A pressure difference of 5.2×10^4 Pa (7.5 psia) between the Rustler and the Bell Canyon was assumed in the analysis.(4) The resulting initial velocity in the wellbore would correspond to that of a porous media with a permeability of 10^5 darcies.

Scenario 2: In this scenario, two 0.6 m (2-ft) diameter wellbores are assumed to fail such that their permeability is 50 times that of the

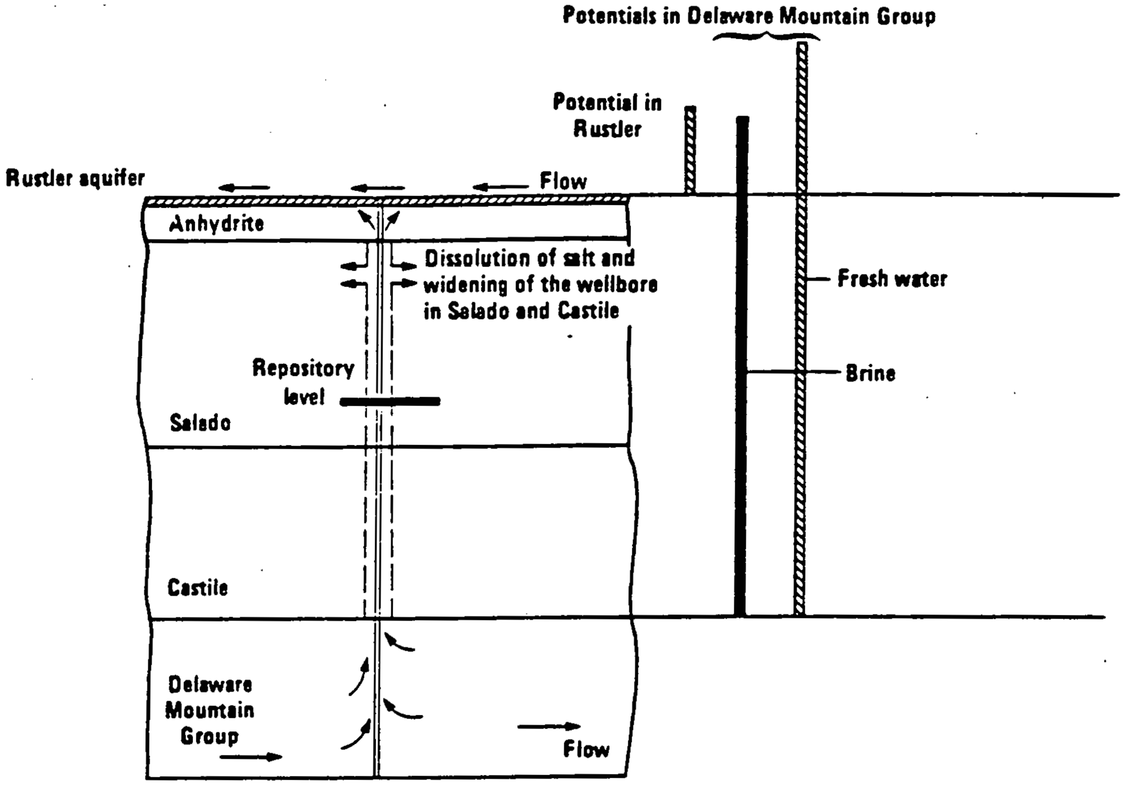

Figure 6. SCHEMATIC OF SCENARIO 1

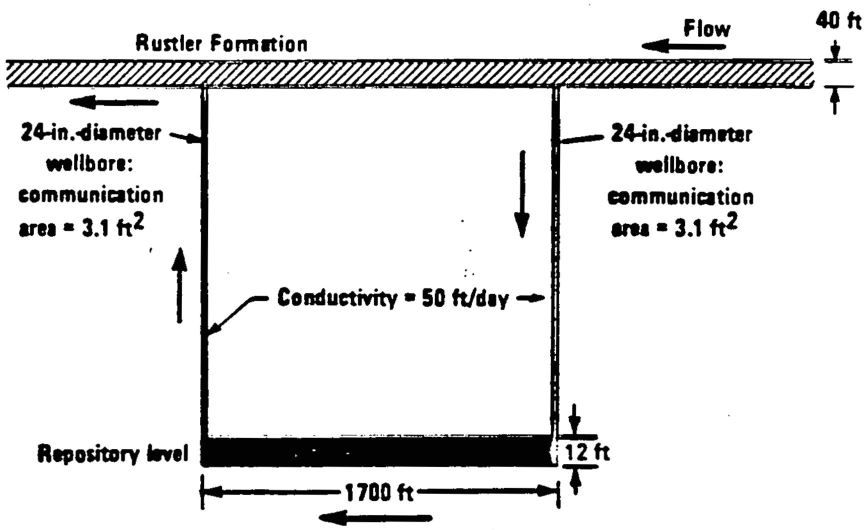

Figure 7. SCHEMATIC OF SCENARIO 2

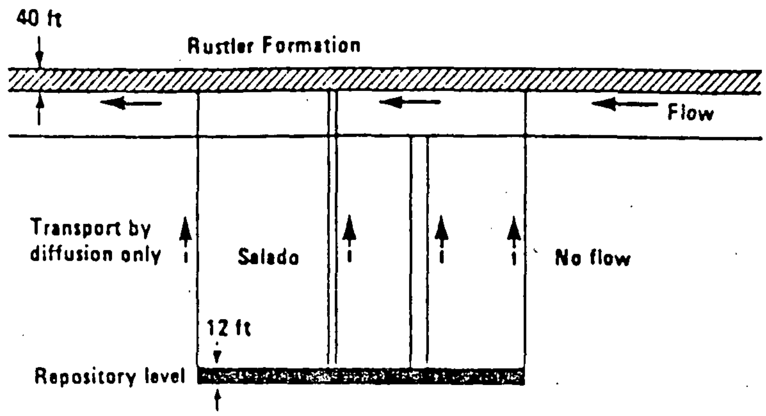

Figure 8. SCHEMATIC OF SCENARIO 3

Rustler aquifer, thus allowing fluid to enter the repository from the Rustler through one hole, dissolve the repository, and then reenter the Rustler through the other hole. Water entering the repository is assumed to contain 8000 ppm dissolved solids. After dissolution of the repository and the wastes, it reenters the Rustler saturated at 410,000 ppm. The conductivity assumed for the shafts and the borehole is equivalent to an effective permeability of approximately 20 darcies.

Scenario 3:

In this scenario, penetrations into the repository are sufficient to allow the repository to flood, although no circuit is established to allow fluid flow. The only mechanism for waste transport is molecular diffusion in the liquid phase. An area of 2 x 10^5 m^2 (50 acres) is assumed to be open between the repository and the Rustler. This area is far larger than could credibly be achieved by any number of unplugged boreholes or shafts into the repository.

In all analyses for WIPP, no credit is given to the stability of the waste form beyond an assumed dissolution rate equivalent to that of the salt in the repository. Radionuclide transport in the aquifers is based on retardation parameters (sorption), which are derived from laboratory data and no credit it taken for sorption in the salt or associated minerals.(10) Transmissivity of the aquifers is varied, and the consequences considered are based on the maximum values measured for a given region. Doses are calculated for the maximally exposed individual.

Results

Results from the consequence analyses discussed above have been obtained for a repository based on the earlier DOE mission for WIPP, which contained both TRU waste and 1000 spent fuel assemblies (1) and for the current design with only TRU wastes.(5,9) Results of the latter case for the maximum scenarios are presented in Table III.

TABLE III

RESULTS OF CONSEQUENCE ASSESSMENTS FOR A TRU REPOSITORY

	Highest Annual Total Body Dose Rate (mrem/year)	Greatest Organ (Bone) Dose Rate (mrem/year)
Scenario 1	7.7×10^{-3}	1.3×10^{-2}
Scenario 2	1.7×10^{-3}	2.8×10^{-3}
Scenario 3	7.0×10^{-5}	1.2×10^{-4}

These results indicate that scenario 1 yielded the highest dose to individuals (7.7×10^{-3} mrem/yr whole body), which is about 0.005% of the dose from natural radiation in the United States.

Additional studies (3) have been performed to assess the sensitivity of the results in Table III to variations in radionuclide sorption in the fluid pathways. These studies concluded that, while sorption near the repositories plays an important role in reducing consequences, sites with favorable geologic and hydrologic settings such as WIPP can tolerate essentially no reliance on sorption and still achieve inconsequential predicted doses from releases from TRU wastes. Additional comparisons of the assumptions for waste form integrity, brine migration, and radionuclide sorption, and the consequence assessments performed here have also been developed.(11)

SUMMARY AND CONCLUSIONS

The Waste Isolation Pilot Plant has been designed for development at a site in southeastern New Mexico. The facility would allow for retrievable disposal of TRU waste and experimentation with defense high-level wastes. The proposed site has been identified by a process that included avoidance of any deep drill holes within one mile of the limit of underground workings. The 7700 hectare (19,000) acre area proposed for Department of Energy control does contain 21 holes drilled by the potash and petroleum exploration industry. In addition, 45 holes have been drilled by the DOE for geologic and hydrologic characterization of the site and for further estimates of potential potash reserves. Of these 66 holes, only 8 penetrate below the proposed repository level. Of these, the 4 that penetrate into underlying formations containing aquifers are greater than 1 mile from the underground workings. Development of the facility would include 4 shafts, the largest of which is 23 feet in diameter. All shafts and drill holes would be plugged in conformance with DOE standards before the repository is decommissioned.

Consequence assessments have been performed to evaluate the potential doses to man from hypothetical breaches of repository integrity. All of the scenarios evaluated have assumed large influxes of fluids from overlying or underlying formations. These influxes could be achieved only with completely unplugged or extremely permeable boreholes. Permeabilities greater than 10 darcies are necessary in all cases to achieve the conditions assumed. Even under these assumptions, the dose to a maximally exposed individual did not exceed .001% of natural background radiation dose.

The principal conclusion from these studies regarding borehole plugging is that criteria for sealing penetrations should be specific to a potential repository site and should be developed from comprehensive safety assessment studies that place requirements for borehole plugs into perspective with other factors that comprise the isolation system.

Although these bounding assessments indicate that a site with a favorable geologic and hydrologic setting such as WIPP can tolerate significant compromises in borehole or shaft seal integrity and in other potential man-made and natural barriers, an experimental program has been established to resolve the uncertainty associated with various technical issues. Specifically, a program has been initiated to develop and evaluate technology for sealing penetrations at the WIPP.(12,13) These studies will quantify the integrity of various sealing methods and determine the measure of additional safety assurance provided by competent borehole seals.

REFERENCES

1. DOE/EIS-0026-D, Draft Environmental Impact Statement, Waste Isolation Pilot Plant, Vols. 1-2, U. S. Department of Energy, Washington, DC, 1979.

2. Presidential Message to Congress, February 12, 1980, "Comprehensive Radioactive Waste Management Program," Weekly Compilation of Presidential Documents, Vol. 16, No. 7.

3. Summary of Research and Development Activities in Support of Waste Acceptance Criteria for WIPP," SAND79-1305, Sandia National Laboratories, November 1979.

4. Geological Characterization Report, Waste Isolation Pilot Plant (WIPP) Site, Southeastern New Mexico, Vols. 1-2, SAND78-1596, Sandia National Laboratories, December 1978.

5. Waste Isolation Pilot Plant Safety Analysis Report, U.S. Department of Energy.

6. Hunter, T. O., "Technical Issues of Nuclear Waste Isolation in the Waste Isolaton Pilot Plant (WIPP)," SAND79-1117C, Sandia National Laboratories. Presented at 87th National Meeting American Institute of Chemical Engineers, Boston, MA, August 1979.

7. Wowak, W. E. and A. R. Sattler, "Criteria and Preliminary Design for WIPP Exploratory Program Experiments, SAND79-2077, Sandia National Laboratories (to be printed).

8. Bingham, F. W. and G. W. Barr, "Scenarios for Long-Term Release of Radionuclides from a Nuclear Waste Repository in the Los Medanos Region of New Mexico, SAND78-1730, Sandia National Laboratories, 1979.

9. Tierney, M. S., et al., "Long-Term Safety Assessments of the WIPP: Final Consequence Analysis," SAND80-1116, Sandia National Laboratories (to be published).

10. Dosch, R. and A. W. Lynch, "Interaction of Radionuclides with Geomedia Associated with the Waste Isolation Pilot Plant (WIPP) Site in New Mexico," SAND78-0297, Sandia National Laboratories, 1978.

11. Hunter, T. O., "The Perspective of Waste Isolation Research Issues and Assessment of Consequences for Radionuclide Release, SAND79-1076C. Presented at the Materials Research Society International Symposium on the Scientific Basis for Nuclear Waste Management, Boston, MA, November 1979.

12. Christensen, C. L. and T. O. Hunter "Waste Isolation Pilot Plant (WIPP), Borehole Plugging Program Description, January 1, 1979," SAND79-0640, Sandia National Laboratories, Albuquerque, NM, August 1979.

13. Christensen, C. L., "Test Plan, Bell Canyon Test, WIPP Experimental Program, Borehole Plugging," SAND79-0739, Sandia National Laboratories, Albuquerque, NM, June 1979.