DOE/WIPP-89-003 SUMMARY

WASTE ISOLATION PILOT PLANT NO-MIGRATION VARIANCE PETITION

EXECUTIVE SUMMARY

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TABLE OF CONTENTS

1.0 INTRODUCTION

The U.S. Department of Energy (DOE) is petitioning the U.S. Environmental Protection Agency (EPA) to allow the emplacement of hazardous wastes subject to the land disposal restrictions in the Waste Isolation Pilot Plant (WIPP). The petition demonstrates to a reasonable degree of certainty that there will be no migration of hazardous constituents from the repository for as long as the wastes remain hazardous.

Title 40 CFR 268.6 identifies specific criteria which must be addressed in making a demonstration of no migration. EPA's approval of this petition will allow the WIPP facility to accept wastes otherwise prohibited or restricted from land disposal.

2.0 BACKGROUND

The federal government has been planning for more than 30 years for the permanent disposal of defense-generated radioactive wastes. Geologic disposal was recommended in 1957 by the National Academy of Sciences (NAS) and, in 1973, the search for a suitable disposal site commenced. The U.S. Geological Survey and the Oak Ridge National Laboratory (ORNL) found that the salt deposits of eastern New Mexico best satisfied stringent site selection criteria, which defined geological, hydrological, and logistical requirements for facility construction and waste isolation. In 1980, the National Security and Military Applications of Nuclear Energy Act authorized the DOE to provide a research and development facility to demonstrate the safe disposal of transuranic waste. Located 26 miles east of Carlsbad, New Mexico, the WIPP facility is a geologic repository constructed in the bedded salt deposits of the Salado Formation.

The wastes intended for emplacement at the WIPP facility result primarily from activities related to the reprocessing of plutonium-bearing reactor fuel and the fabrication of plutonium-bearing weapons. The wastes consist largely of such items as laboratory glassware and utensils, tools, scrap metal, shielding, and solidified sludges from the treatment of wastewaters. In addition to being radioactively contaminated, the wastes frequently contain materials considered hazardous. Trace amounts of degreasing solvents may remain on a tool or piece of glassware, for example, and rubber aprons and gloveboxes are lined with lead.

The "cradle to grave" management of hazardous wastes is regulated under the Resource Conservation and Recovery Act (RCRA) of 1976, which is administered by the EPA and authorized state agencies. In 1984, RCRA was amended and stringent new provisions were added that prohibit the land disposal of hazardous wastes, unless treatment standards established by EPA are met or the wastes are subject to an EPA-approved variance or exemption. The EPA did not formally determine that the hazardous waste components of radioactive mixed wastes were subject to regulation under RCRA until July 3, 1986.

Solvents and "California List" wastes had been restricted from land disposal when DOE and EPA began to evaluate the impacts of extending the land disposal restrictions to radioactive mixed wastes. In promulgating restrictions for the first third of remaining wastes in August 1988, the EPA postponed placing any further restrictions on the land disposal of mixed waste until May 8, 1990, the statutory deadline for promulgating the final set of restrictions. This postponement allows time to examine such issues as the availability and effectiveness of demonstrated treatment technologies for radioactive mixed wastes and the potential environmental and human health impacts of exposure to radiation during treatment.

The solvent and California List restrictions still apply to mixed waste. This petition addresses these and all remaining hazardous constituents, including those that are not yet restricted and currently may be land disposed without a variance.

3.0 TECHNICAL REQUIREMENTS

Section 3004 of RCRA allows EPA to grant a variance from the land disposal restrictions when a demonstration can be made that, to a reasonable degree of certainty, there will be no migration of hazardous constituents from the disposal unit for as long as the waste remains hazardous. Specific requirements for making this demonstration are found in 40 CFR 268.6, and EPA has published a draft guidance document to assist petitioners in preparing a variance request. Throughout the course of preparing this petition, technical staff from DOE, EPA, and their contractors have met frequently to discuss and attempt to resolve issues specific to radioactive mixed waste and the WIPP facility. The DOE believes it meets or exceeds all requirements set forth for making a successful "no-migration" demonstration.

The petition presents information under five general headings: (1) waste information; (2) site characterization; (3) facility information; (4) assessment of environmental impacts, including the results of waste mobility modeling; and (5) analysis of uncertainties. Additional background and supporting documentation is contained in the 15 appendices to the petition, as well as in an extensive addendum published in October 1989. The following sections summarize all the information that has been presented to support the petition, including that contained in the addendum.

4.0 WASTE INFORMATION

According to EPA guidance, the waste properties of particular concern with regard to emplacement in geologic repositories are those that could impact waste mobility or repository stability, such as volatility, ignitability, reactivity, corrosivity, solubility in water, and susceptibility to phase or species transformation. Petitioners for a no-migration variance must characterize, to the extent possible, each waste to be emplaced in the unit. The following is a description of the wastes that will be emplaced in the WIPP facility.

4.1 <u>WASTE GENERATORS AND STORAGE LOCATIONS</u>

The wastes considered for emplacement in the WIPP facility are currently generated by the following DOE installations:

- Idaho National Engineering Laboratory (INEL), Idaho Falls, Idaho
- Rocky Flats Plant (RFP), Golden, Colorado
- Los Alamos National Laboratory (LANL), Los Alamos, New Mexico
- Argonne National Laboratory-East, Argonne, Illinois
- Savannah River Plant (SRP), Aiken, South Carolina
- Oak Ridge National Laboratory (ORNL), Oak Ridge, Tennessee
- Hanford Reservation (HANFORD), Richland, Washington
- Mound Plant (MOUND), Miamisburg, Ohio
- Lawrence Livermore National Laboratory (LLNL), Livermore, California
- Nevada Test Site (NTS), Mercury, Nevada

Each facility operates its own retrievable storage facilities for the wastes it generates, with the exception of RFP, LLNL, Mound and Argonne. These facilities store their wastes at INEL, NTS, INEL, and INEL, respectively.

4.2 WASTE TYPES AND SOURCES

The DOE has designed, developed, tested, and produced nuclear weapons for more than 40 years. Plutonium fabrication and reprocessing operations result in the contamination of large volumes of tools, equipment, protective clothing and other items which can no longer be used. Contaminated liquids treated by wastewater treatment facilities generate contaminated sludges, and some contaminated liquid laboratory wastes are cemented and drummed. Finally, decontamination and decommissioning activities at DOE installations have generated additional contaminated items that require proper disposal.

These wastes are termed "transuranic" (TRU) wastes because they are contaminated with alpha-emitting radionuclides having half-lives in excess of 20 years with atomic numbers greater than 92 (that is, heavier than uranium) in concentrations greater than 100 nanocuries per gram of waste. They are not as intensely radioactive as high-level wastes, do not generate as much decay heat, and require little or no additional shielding. Some wastes are co-contaminated with fission products, however, and must be remote-handled. TRU radionuclides require a long time to decay, as their half-lives are typically hundreds or thousands of years, and their disposal must provide long-term isolation from the biosphere.

The WIPP facility will accept only defense-generated TRU wastes. However, a portion of the waste that will be emplaced is also contaminated with materials considered hazardous. This hazardous waste component is subject to regulation by EPA under RCRA, and consists largely of the following:

EP Toxic Metals. Cadmium, chromium, lead, mercury, selenium and silver (EPA codes D006-D011) are present in discarded tools and equipment, solidified sludges, cemented laboratory liquids, and wastes from decontamination and decommissioning activities. Lead is by far the most prevalent EP toxic metal present. A large percentage of the waste consists of lead-lined gloves, aprons and gloveboxes, lead bricks and piping, and other lead items. Unless analytical data indicate otherwise, the DOE assumes all metals identified in the waste to be present in EP toxic concentrations, although in many cases only very small trace amounts may exist.

Halogenated Organic Compounds. Tetrachloroethylene; trichloroethylene; methylene chloride; 1,1,1-trichloroethane; carbon tetrachloride; and 1,1,2-trichloro-1,2,2-trifluoroethane (EPA codes F001 and F002) are the primary halogenated organic compounds identified in wastes that will be shipped to the WIPP facility. These compounds are used commonly as degreasing solvents to clean metal surfaces prior to plating, polishing or fabrication, to solubilize other compounds, or as coolants. Because they are highly volatile, only very small amounts typically remain on equipment after cleaning or, in the case of treated wastewaters, in the sludges after clarification and flocculation. All halogenated organic compounds identified by waste generators as having been used in any activity or process are considered by DOE to be potentially present in the waste.

Nonhalogenated Organic Compounds. Xylene, acetone, methyl alcohol, and butyl alcohol are the primary nonhalogenated compounds identified in wastes that will be shipped to WIPP. They, too, are used as degreasers and solubilizers, and are similarly volatile. Under EPA's method for hazardous waste identification, these wastes are listed under the F003 code due to their potential ignitability. When mixed with other waste materials, such mixtures are not regulated under RCRA if they do not meet the ignitable characteristic criteria. The waste mixtures to be emplaced in WIPP are not ignitable; however, the DOE will manage them as hazardous wastes. They are identified in the petition as "hazardous constituents potentially present in the waste."

Waste Characterization Methodology. The hazardous components of TRU mixed wastes are characterized through a multistage process utilizing existing data, generator knowledge of the wastes, real-time radiography, and limited analyses. This process yields information on the potential hazardous constituents (or properties) present, their physical form and relative volumes.

An initial survey of TRU mixed waste generators was undertaken, using preexisting waste information as a starting point. The DOE had already classified the wastes into "waste forms" based on the physical characteristics of the material. Examples of waste forms are "solidified aqueous sludges," "filters" and "metals." Because the waste forms are largely process-specific, the generators were asked to identify the hazardous materials entering each process for each waste form. The survey was conducted from an "input" rather than an "output" perspective, resulting in the identification of all hazardous constituents that could be potentially present in the wastes. Such an approach takes no credit for the consumption or removal of a constituent during a production process, and thus is highly conservative.

Verification of the physical waste form is provided by real-time radiography (RTR) and visual examination. RTR is an x-ray technique that permits examination of a container's contents without the need for opening the container and exposing workers to radiation. RTR is an effective tool for identifying free liquids, bulk particulates, metallic objects, and other items and materials (it can detect liquid ink in a ballpoint pen, for example). Visual examination of containers after inspection through RTR have confirmed the effectiveness of the technique as well as the reliability of historical records.

Finally, available analytical data were reviewed. The TRU Waste Sampling Program and the ongoing program, the Stored Waste Examination Pilot Plant (SWEPP) Certified Waste Sampling Program conducted at the Idaho National Engineering Laboratory, have provided verification of waste characterization information obtained from existing records, process knowledge, and RTR. The results of container headspace gas analyses indicate that the source of volatile organic compounds in the waste is limited and that the physical and chemical forms of the wastes restrict the release of vapors into the headspace of containers. Additional headspace gas samples will be analyzed as part of a more comprehensive waste characterization effort undertaken during the initial test phase.

In addition, some inorganic and organic sludge in stored waste of various ages from the Rocky Flats Plant were analyzed for total halogenated and nonhalogenated organic compounds. These results further confirmed that the source of volatile organic compounds is limited in the waste. Toxicity Characteristic Leaching Procedure (TCLP) analyses were also performed on a limited number of inorganic sludges from the Rocky Flats Plant. Most hazardous constituents were below detection limits, and all were below the treatment standards established in 40 CFR §268.41.

More recent waste characterization efforts include the development of "process flow" diagrams for each DOE facility which describe specific production and research activities and the wastes generated by each. These are intended to comprehensively document qualitative waste characterization data and are included in the waste analysis plan provided in the petition.

4.3 WASTE PROPERTIES AND TRANSFORMATION MECHANISMS

Changes in the waste are likely to occur over time, as radiolytic and microbiological processes affect temperatures, degrade organics, generate gases, and alter the chemistry of brine (e.g., Eh and pH), if present, in the area immediately surrounding the wastes. Changes in temperature are expected to be slight and may increase the rate of other processes to some extent. The degradation or microbial decomposition of organics should render them nonhazardous, although gases such as carbon dioxide, carbon monoxide, methane, oxygen and hydrogen will be produced. The breakdown of plastics, paper, rubber and other solid wastes will contribute the largest portion of decomposition products. Acids may also be produced, but the excess of basic cement used in waste solidification will neutralize them.

The rate at which gases will be generated within the repository is not currently known. Excessive pressurization of the repository, if it occurs at all, may occur in the period after repository closure. To determine the rate of gas generation within the repository, experiments will be conducted during the test phase. The results will be used to determine whether engineering changes to the facility or other measures are necessary to ensure the long-term integrity of the repository.

4.4 WASTE COMPATIBILITY

The waste to be emplaced in the WIPP facility is limited to solid or solidified material. No corrosives, explosives, or pyrophorics will be placed in the repository. These restrictions are detailed in the WIPP Waste Acceptance Criteria (WAC). Prior to shipment, each waste container must be certified to be in compliance with the WAC. The certification program is described in both the petition and the addendum.

All materials to be emplaced must be compatible to ensure that reactions or byproducts do not threaten human health, the environment, or the integrity of the repository. Chemical compatibilities were considered from several perspectives: waste-waste interactions, waste-brine interactions, waste-salt interactions, and waste-seal interactions.

Waste-Waste Interactions. As a follow-up to the survey conducted to identify the potential hazardous constituents within each waste form, waste generators were asked to quantify the amounts of all materials that could be present, including nonhazardous materials. The materials were first grouped according to their nature and structure - acids, minerals, nonoxidizers, and caustics, for example. The quantification of materials was expressed as "trace" (less than 1 percent), "minor" (1 to 10 percent), and "dominant" (greater than 10 percent).

A computer program was developed based on EPA's "Method for Determining the Compatability of Hazardous Wastes." This method utilizes the same groupings to identify potential incompatibilities between wastes. For example, a reaction between Group 1 (acids, minerals, and nonoxidizers) and Group 10 (caustics) could result in the generation of heat. The computer program is able to examine the compatibility of all materials potentially present in the wastes.

Because the original waste data base was based on process inputs, the computer analysis identified several potential incompatibilities that were easily resolved. After a case-by-case examination, most of the incompatibilities were found to be reactions between materials entering a process, such as acids and caustics. By the time a process had reached its final stage and the wastes were generated, any reactions between the incompatible materials had already occurred; in the example above, the materials had been neutralized. Any wastes for which an identified incompatibility could not be resolved were segregated, and the generator was informed that the waste could not be shipped unless testing showed the waste to pose no actual concern. These precautions will prevent waste-waste incompatibilities within the repository.

The DOE will conduct experiments during the test phase to obtain further information on the effect of radiolysis on organic compounds, both hazardous and nonhazardous. Although the results are not expected to change any predictions regarding repository integrity and long-term waste isolation, they will contribute significantly to the body of knowledge on this subject.

Waste-Brine Interactions. The small amount of brine that may seep into the repository in the long-term will limit any chemical interactions with the wastes present. The brine itself does not contain strong oxidizers or reducers that could cause a violent reaction with the waste. The ionic strength of brine is ten times greater than seawater, and it will solubilize heavy metals, though the total amount of solubilized metals is expected to be very small because of the limited volume of brine expected.

The primary waste-brine interaction will be the corrosion of metals. This reaction produces hydrogen gas that can be flammable in high concentrations. Within the repository, however, there will be only limited oxygen during the time period when the majority of gases are expected to be generated, limiting the likelihood of fire. (As previously noted, experiments conducted during the test phase will quantify the rate of gas generation by all mechanisms, including the corrosion of metals.) Thus, hydrogen or other explosive gases that may be present are not expected to present a risk to repository integrity.

The DOE will conduct experiments during the five-year test phase to obtain further information on the effects of radiolysis on brine chemistry. Although results are not expected to change predictions regarding repository integrity and long-term waste isolation, they will contribute significantly to the body of knowledge on this subject.

Waste-Salt Interactions. No chemical incompatibilities exist between the waste itself and the salt of the Salado Formation. Physically, liquids can dissolve salt, but the TRU wastes contain only minute amounts of residual liquid as compared to the total volume of other materials and this will be absorbed by the backfill of predominantly crushed salt. Very little salt could be dissolved before the water becomes saturated (as in the case of brine), and the impact to the repository is expected to be insignificant.

Waste-Seal Interactions. The proposed shaft seals will be constructed of crushed salt, concrete and bentonite. The salt will solidify over time to approach a density equal to the host rock; the function of the concrete and bentonite is to provide a short-term seal and to hold the salt in place until consolidation occurs.

Seal integrity in the short term relies on the compatibility of the waste constituents with concrete and bentonite. Because only residual liquids will be placed in the repository, any hazardous constituents that could reach these seal materials would have to be dissolved in brine or in vapor form. Limited brine inflow and the fact that brine is already saturated with salt make the likelihood of this event minimal. The interactions between concrete and bentonite with organic vapors is limited by the small amount of volatile organics initially present in the waste. The waste containers are vented prior to shipment, and the repository itself will be ventilated during emplacement operations. The short-term seals will not be exposed to a saturated environment of organic vapors, and thus no impacts of significance are expected to occur.

Experiments during the test phase will include studies to determine the rate of gas generation within the repository. (The DOE has provided a copy of the current Test Plan to the EPA as supplementary information to the petition.) Tests will also define more precisely the rate of brine inflow. The results of both sets of tests will be used to evaluate the proposed seal materials as well as to guide the final seal design. It is unlikely that waste-seal incompatibilities will occur; however, further tests using simulated waste-brine mixtures may be performed to examine their chemical and physical interactions. The DOE will take any additional steps necessary to ensure that the shaft seals function properly.

5.0 SITE CHARACTERIZATION

Geology and hydrology are important site characteristics with regard to waste isolation. The WIPP site has a long history of study and evaluation directed at these and other environmental factors. A complete bibliography of literature on the environment of the WIPP site is included in the petition and supporting materials, as well as a thorough description of all pertinent local and regional characteristics.

5.1 GEOLOGY

Geologic disposal of TRU wastes has been studied intensively for more than 30 years. The National Academy of Sciences recommended disposal in salt beds and salt domes because the very existence of these formations, created millions of years ago by the evaporation of ancient seas, indicates that they are free of unsaturated water which could, because salt is so soluble, cause dissolution or create openings. The beneficial lack of openings and water eliminates an otherwise potential transport mechanism for waste migration to the surface or to ground water.

Another advantage of salt is that it is plastic; that is, under heat and the lithostatic pressure found in deep geologic repositories, it will flow to heal any openings created by excavation or natural causes. Wastes emplaced in such a medium will become completely encased in a few decades, and in tectonically stable areas, could be expected to remain in place and isolated from the biosphere for geologically long periods of time.

Geologic History. The Delaware Basin is part of the larger Permian Basin, located in the southwestern part of the central region of North America. During the Permian period, which came to a close about 225 million years ago, ancient seas covered the basin. Their later evaporation resulted in the deposition of salt and other marine materials in great abundance. Three major evaporite-bearing formations were created in this manner:

- The *Castile Formation*, formed through evaporation of the Permian Sea, which deposited carbonates, anhydrites and halite (salt). Its upper boundary is at a depth of about 2,825 feet, and its thickness near the WIPP facility is about 1,500 feet.
- The *Salado Formation*, in which the repository is constructed, overlies the Castile and resulted from prolonged desiccation that produced cycles containing some carbonates and anhydrites, but predominantly halite. Its upper boundary is at a depth of about 850 feet and it is about 2,000 feet thick at the repository.
- The *Rustler Formation*, deposited in a lagoonal environment during a major freshening of the basin, consists of carbonates, anhydrites and halites. Its beds are comprised mostly of clay and gypsum and contain small amounts of brine. The Rustler Formation's upper boundary is about 500 feet below the surface and it ranges up to 560 feet in thickness.

These evaporite-bearing formations lie between two other formations significant to the geology and hydrology of the WIPP site. The *Dewey Lake Red Beds* overlying the Rustler Formation were formed through terrestrial rather than marine processes (such as the deposition of river sediments), consisting almost entirely of mudstone, claystone, siltstone, and interbedded sandstone. This formation forms a 650-foot thick barrier of fine-grained sediments which retard the downward percolation of water into the evaporite units below. The *Bell Canyon Formation* is the first water-bearing unit below the Salado. It is confined by the thick evaporite sequences of the Castile Formation above. It consists of 1,500 feet of interbedded sandstone, shales and siltstones.

The Salado Formation was selected to host the WIPP repository for several reasons. Its permeability is extremely low, and fluids within it are effectively immobile. Mechanically, salt behaves in a plastic manner under pressure (the pressure at the facility horizon is more than 2,000 psi) and readily recrystallizes to heal cracks or openings. Any fluid remaining in small fractures or openings is saturated with salt, incapable of further dissolution, and may remain in place for millions of years. Bedded salt formations also tend to be a really extensive; the Salado underlies an area of more than 36,000 square miles. Finally, the Salado is sandwiched between the Rustler and the Castile formations, which themselves are highly impermeable and will act to further confine and isolate wastes within the WIPP repository.

Geomorphology. The terrain of much of southeastern New Mexico is characterized by a gentle, southwesterly slope and rolling surface marked by karst features, caliche, and sand dunes. The Pecos River, 14 miles west of the WIPP site, is the nearest major perennial stream and receives almost all the surface drainage in this region and a large part of its subsurface drainage.

Nash Draw is the nearest major geomorphic feature, located about five miles south of the WIPP site. It is an undrained physiographic depression resulting from differential dissolution of portions of the Rustler and upper Salado formations. Dissolution also produced numerous small sinkholes within the draw. In the immediate area of the WIPP facility, however, post-depositional dissolution in the Rustler has been minor, reducing its thickness by, at most, a maximum of 30 feet. There has been no dissolution of the Salado within the site area.

The dissolution which formed these features occurred during wetter climatic periods following the deposition of the evaporite units. During the period of greatest dissolution, only evaporites located within 200 feet of what was then the surface were affected. Most, if not all, of the depressions in the immediate vicinity of the WIPP site are the result of the erosion and deposition of wind-blown sand, not the dissolution of underlying evaporites. Two major factors halted evaporite dissolution and suggest that its future occurrence is highly improbable:

- Water remaining in the evaporite deposits is saturated with respect to halite; such brines are incapable of further dissolution; and

- Geologic units above the Salado are confining layers with extremely low transmissivity; they prevent any infiltration of water from the surface.

In addition, a thick layer of Mescalero caliche is found near the surface. Formed in mid-Pleistocene time, the presence of caliche indicates the absence of significant erosion, creating one of the most stable landscapes in the world. At the WIPP facility, the caliche is about 10 feet thick and, where well developed, all available porosity in its upper zone is plugged with calcium carbonate, forming a barrier to the downward infiltration of the small amount of precipitation that falls in this area.

Geologic Stability. No surface faults have been mapped within five miles of the center of the WIPP site, and those beyond are related to the dissolution and collapse of soluble materials rather than to tectonic activity. Deep-seated faults of tectonic origin are present throughout the Delaware Basin, but movement along these faults ceased well before deposition of the evaporite units. The Bell Lake Fault in Lea County, New Mexico, is the closest such structure to the WIPP facility, with approximately 500 feet of displacement. There are no folds of tectonic origin in the area of the WIPP site, although some thickening of the Salado associated with gravity-driven salt movement in the Castile has been observed.

5.2 GROUND WATER HYDROLOGY

The WIPP facility is located in the Salado Formation because it is hydrologically isolated and because the plastic nature of the salt causes any potential fractures to heal before they could spread to connect with any water-bearing formation. The hydrology of the area surrounding the WIPP facility is described below in ascending order.

Bell Canyon Formation. The uppermost sandstones of the Bell Canyon Formation, the Ramsey Sandstone Member, contain unsaturated brine with sufficient equivalent freshwater head to reach the Rustler Formation overlying the Salado. It is likely, however, that such brines would dissolve additional salt when passing upward through an uncased borehole through the Salado. As a result, those denser fluids would no longer have sufficient head to reach the Rustler Formation. The sandstones are surrounded by siltstones of very low permeability, and the Bell Canyon Formation itself is confined by thick evaporite deposits of the Castile.

Castile Formation. The Castile Formation is a basin-filling evaporite sequence of sediments that is surrounded by the Capitan Reef and was deposited in the basin outlined by it. The Castile represents a major regional ground water aquiclude that effectively prevents any water from moving up from the Bell Canyon Formation below. Any fluid present in the Castile is very restricted, because evaporites do not readily maintain pore space, solution channels, or open fractures at depth. Drill stem tests conducted in the Castile during construction of the WIPP facility found its permeability too low to be measured; however, the hydraulic conductivity has been conservatively estimated to be less than 10^{-8} feet/day.

It has been suggested that dissolution of the Salado salts could occur if a flow path developed through the Castile to allow the upward movement of unsaturated brines in the Ramsey Sandstone Member. However, detailed studies of the logs and cores from drilling in the vicinity of the WIPP facility have failed to identify fractures or other evidence that water has moved vertically through the evaporite sequences. On the basis of numerical modeling, it has been suggested that, should such an event occur, salt removal through the Castile would advance at a rate of about 0.1 inch in 10,000 years.

Another issue associated with the hydrology of the Castile Formation is the presence of isolated zones of pressurized brine. Two brine reservoirs were encountered by drillholes during WIPP site characterization activities. The volumes of the ERDA-6 and WIPP-12 brine reservoirs are estimated to be 75,000 and 2,000,000 cubic meters, respectively. The brine is pressurized and capable of discharging to the surface under artesian conditions. Most of the brine is stored in low-permeability microfractures, with only about 5 percent present in large open fractures. There are two theories regarding their origin. One theory is that the fluids originated from ancient seawater. The other is that they were transmitted to the Castile through an episodic connection with the Capitan Reef. In any event, the brines are saturated with respect to halite and have no further dissolution potential.

Salado Formation. The Salado Formation is also an evaporite sequence that filled up the basin and lapped extensively over the reef and the back-reef sediments beyond. It acts hydrologically as a regional confining bed and does not contain any circulating fluids. The porosity of the Salado halite is very low, and interconnected pores are virtually nonexistent at this depth. Fluids within the Salado occur mainly in very small fluid inclusions within the halite crystals and between crystal boundaries ("interstitial" fluid) within the massive, crystalline salt. Measured permeabilities in the area of the WIPP facility are in the range of 0.01 to 25 microdarcies, averaging 0.3 microdarcy. As a comparison, the permeability of the Salado is roughly a thousand times more restrictive than the lower clay liner required of surface impoundments and landfills, assuming similar thicknesses. It has been suggested that far-field permeabilities in undisturbed rock may approach zero.

Several features of the Salado Formation have been extensively evaluated with regard to their potential impacts to repository integrity:

- *Pressurized Gas* - Pressurized gas has been encountered within the Salado in surface boreholes, local mines and WIPP excavations. Because gas has been encountered only in disturbed rock associated with drilling and excavation, it is likely the gas exsolved from brine as surrounding pressure was relieved.

- *Brine Seepage* - The brine seeps observed in the WIPP excavations have received considerable attention. While the Permian salt beds of the Salado Formation are considered to be "dry" in that the inflow of brine is virtually nonexistent, very small volumes of brine have been observed to "weep" from surfaces in the WIPP excavations. The moisture readily evaporates, leaving behind thin salt crusts that build up over time. The brine is not derived from inclusions, but is interstitial fluid that, prior to disturbance, had been in place for at least several million years. Brine has also been observed to accumulate in drillholes, with measured inflow rates ranging from less than the rate of evaporation to 0.13 gallon per day. The rate of inflow is noted to decrease with time.

  Sandia National Laboratories has modeled the rate of brine seepage and estimates that the expected brine accumulation in a waste disposal room will be in the range of 141 to 1,518 cubic feet, the maximum value representing 1.2 percent of the initial room volume. This is within the range of the amount of brine easily released by the excavated salt. The WIPP facility disposal rooms, after backfilling, are expected to reconsolidate to virtually the same density as the surrounding host rock in about 100 years. The backfill materials will readily absorb the maximum expected brine accumulation while maintaining its mechanical strength. The small amounts of brine that will seep into the excavations are not viewed as posing any significant technical problem to the safe disposal of waste.

- *Marker Bed Undulations* - Marker Bed 139 (MB 139) directly underlies the WIPP facility and is characterized as a layer of polyhalite, anhydrite and halite slightly more than three feet in thickness. Investigation of MB 139 was prompted by concern that its undulating surface developed in response to some late-stage stress which might affect the integrity of the WIPP facility. Two separate studies concluded that the undulations did not result from stress; rather, the upper surface of the marker bed had been unevenly deposited.

- *Marker Bed Fractures* - Preexisting fractures in MB 139, partially to wholly filled with halite, were formed in response to loading or, less likely, structural deformation in the Castile. These preexisting fractures provide planes of weakness which reactivate in response to the near-field stresses generated by excavation. Separation along these fractures in the floors of WIPP rooms and drifts has occurred, with the amount of separation measuring up to several centimeters in width. The fracture separations are a temporary, short-term response to stress relief and are expected to close over time, as the repository excavations creep shut and repressurize.

- *Disturbed Rock Zone* - Following the excavation of underground openings at the WIPP horizon, a disturbed rock zone (DRZ) forms in the wall rock. The DRZ is defined as the zone of rock in which mechanical and hydrologic properties have changed in response to the excavation. The marker bed fractures described above are part of the DRZ, which also includes an area of dilation and microfracturing along the excavation walls and extending into the surrounding rock mass to a depth of up to five meters. The potential impacts of the DRZ have been investigated, and will continue to be examined during the test phase, particularly with regard to the maintenance of excavated openings during operations, behavior at the seal/rock interface, and brine inflow.

Rustler-Salado Contact. Away from the WIPP site in the vicinity of Nash Draw, the contact of the Rustler and Salado formations is evidenced by a layer of thinly-bedded clay and brecciated gypsum averaging 24 feet in thickness and containing brine. The hydraulic gradient in this layer is southwest across the region to Nash Draw. Transmissivity ranges from $3x10^{-5}$ to $5x10^{-2}$ ft^2/day. The water contained in this unit is saturated with respect to halite and is incapable of further dissolution. This brecciated water-bearing zone is not seen in the shafts at WIPP and is not a factor affecting the containment of waste at the WIPP facility.

Rustler Formation. The Rustler Formation has been the subject of extensive characterization activities, as it contains the most transmissive hydrologic units overlying the Salado. Within the Rustler, five hydrologic units have been identified. Of these, the Culebra Dolomite Member is the most transmissive and has been the focus of most of the Rustler hydrologic studies.

The Culebra Dolomite Member is the first continuous water-bearing zone above the Salado and ranges up to 30 feet in thickness. Water in the dolomite is usually present in fractures and is confined by overlying gypsum or anhydrite and underlying clay and anhydrite beds. Its hydraulic gradient in the area of the WIPP facility is about 20 ft/mile, and becomes much flatter south and southwest of the site. Transmissivities in Nash Draw range up to 1,250 ft^2/day; closer to the WIPP facility they are as low as 0.007 to 74 ft^2/day. The Culebra is hydrologically confined, and testing indicates no leakage between it and other units.

Use of water from the Culebra Dolomite is quite limited because of its varying yields and high salinity. Its nearest use is about seven miles southwest of the WIPP facility, where salinity is low enough to allow use for stock watering.

5.3 <u>SURFACE WATER HYDROLOGY</u>

The WIPP facility is located near the edge of the Chihuahuan Desert with an arid to semiarid climate. The mean annual precipitation in the region is about 12 inches, and mean annual runoff is up to 0.2 inch. The maximum recorded 24-hour precipitation at Carlsbad was 5.12 inches in August 1916. The potential evaporation is much greater than the annual precipitation. Almost all water that infiltrates the soil's surface is retained above the extremely impervious caliche and then is lost through evapotranspiration.

No natural drainage features exist at the WIPP site, which is situated more than 400 feet above the 100-year floodplain of the Pecos River. A few small unnamed drainage channels constitute all the tributaries to the Pecos River within 50 miles north or south of the site.

6.0 FACILITY INFORMATION

The WIPP facility is owned by the Department of Energy. The WIPP project was authorized by Congress to provide a research and development facility to demonstrate the safe disposal of TRU wastes resulting from national defense activities and programs.

To meet this objective, the WIPP facility initially will serve as an experimental pilot plant. The experiments to be conducted during the test phase have been described previously. These and other tests will be performed at laboratory- , bin- , and alcove-scales. The results will be used to collect, interpret, and refine data necessary for the performance assessment required by 40 CFR Part 191 for radioactive waste disposal. The data will be evaluated to determine if additional measures are necessary to ensure that no migration of hazardous constituents occurs beyond the unit boundary.

During the test phase, all wastes emplaced will be readily retrievable. In this manner, should the results of evaluations undertaken during the test phase indicate that the WIPP facility is not the appropriate location for the permanent isolation of these wastes, they can be removed with minimal risk. The DOE has prepared a retrieval plan that describes the requirements for waste removal; this plan, summarized in the petition, addresses requirements for retrieval of wastes emplaced as part of the alcove- and bin-scale tests undertaken during the test phase. A retrieval readiness program has been developed to provide training of personnel and to practice waste retrieval operations with nonwaste material. Throughout the actual waste retrieval operation, monitoring programs for radiological and hazardous waste contamination control will be in place to facilitate compliance with the "no-migration" requirement.

The facility will enter full-scale operations upon successful completion of the test phase and demonstration of compliance with all relevant regulatory requirements. The petition provides a detailed description of the facility and all waste handling procedures.

6.1 FACILITY DESCRIPTION

The WIPP facility is located in Eddy County, New Mexico, 26 miles east of Carlsbad. The site consists of 16 sections of federal land under the jurisdiction of the U.S. Department of the Interior, Bureau of Land Management. These lands were withdrawn from public use by Public Land Order 6403 (48 FR 31038), which authorized the use of the land for the construction of the WIPP facility. In August 1987, the DOE and the State of New Mexico agreed to prohibit in perpetuity all subsurface mining, drilling, or resource exploration unrelated to the WIPP Project on the WIPP site.

At the present time, the federal government owns the entire surface and subsurface estate at the WIPP site, with the single exception of a 1,600-acre potash leasehold interest held by I.M.C. Fertilizer, Inc. (IMC). The DOE is actively engaged in negotiations with IMC to purchase the leasehold interest, and the EPA will be apprised of the outcome of these negotiations.

Surface Structures. The Waste Handling Building is the largest surface structure at the facility. It is divided into several separate areas: a contact-handled (CH) TRU waste handling area, a remote-handled (RH) TRU waste handling area, a vehicle maintenance facility, and several support areas such as offices, a health physics laboratory, and change rooms. Safety equipment and measures for controlling radiation and hazardous materials exposure were included in the design of the building and throughout the entire facility.

Underground Structures. The underground portion of the facility is constructed at a depth of 2,150 feet and is located in the Salado Formation. Constructed in a "room and pillar" arrangement, the underground facility will consist of two main areas: a waste disposal area (100 acres), and a research and development area (12 acres). Drifts (tunnels) connect these areas to each other and to the shafts. The rooms themselves are laid out in a series of panels (rows), and there will be eight panels of seven rooms each by the time the facility is completed. Excavated salt is removed through the salt-handling shaft and will be used later, in part, to backfill the rooms and panels. Wastes will be emplaced in both the rooms and the drifts. The facility's total design capacity for waste is 6.2 million cubic feet of CH waste and 250,000 cubic feet of RH waste.

Shafts. There are four shafts to the underground: a salt-handling shaft, a waste shaft, an exhaust shaft and an air-intake shaft. The Waste Shaft is the closest to the disposal area. Each shaft is designed to retain adjacent unconsolidated sands and soils and to prevent the entrance of surface runoff. A circular reinforced-concrete section, termed a shaft key, resists lateral pressures and prevents the shaft liner from separating or failing under tension. Each shaft also contains five water seal rings; if water is detected flowing past the rings, chemical sealants or cement grouts can be injected to stop the leakage.

Facility Boundaries. Aboveground, the 16-square mile WIPP site boundary is divided into several control areas. Zone I, surrounded by a chain-link fence, is the inner area and includes all major surface structures, such as the Waste Handling Building. Zone II is the maximum extent of underground development. The WIPP site boundary extends one mile beyond the maximum extent of underground development. Its shape conforms to the parcels of land withdrawn from public use.

Underground, the unit boundary delineates the volume of salt within the Salado Formation that is permanently reserved for the WIPP facility. The withdrawal of the land from public use is intended to prevent any future drilling on the site or intrusion into the repository. Permanent markers using text and symbols will mark the surface boundary after closure; deed notices and other administrative controls will alert future generations to the restrictions placed on the site. Thus, the WIPP site boundary also serves as the outermost barrier with regard to the underground repository. Other barriers include plugs and seals used in the shafts and tunnels, and the backfill materials around the wastes. The uppermost extent of the Salado Formation is the point-of-compliance for the purpose of modeling waste transport after closure.

6.2 WASTE HANDLING OPERATIONS

Petitioners for a no-migration variance are required to describe waste handling procedures at each facility. Appropriate waste handling procedures are those which comply with regulatory requirements, provide a high degree of safety to workers, and prevent releases of hazardous substances to the environment.

Pre-Transportation Certifications. Prior to shipment to the WIPP facility, wastes must be certified to meet the WIPP WAC. The WAC specifies the chemical, physical and radiological characteristics of the waste to ensure safe disposal in the repository. Each container of CH TRU wastes must be additionally certified to meet the Transuranic Package Transporter II (TRUPACT II) Authorized Methods for Payload Control (TRAMPAC) requirements. The TRAMPAC specifies packaging and payload requirements for compliance with the Nuclear Regulatory Commission (NRC) certification conditions for the TRUPACT II for shipment of Type B quantities of waste to the WIPP facility.

To identify each container of waste, a bar code will be applied at the generator site. Each bar code will contain a unique identification number and information necessary to identify contents and surface radiation dose.

Waste Tracking During Transportation. During transportation to the WIPP facility, the TRANSCOM satellite communication system will track each shipment and provide continuous, real-time feedback to DOE of the status of each shipment. Anomalies, such as route changes and delays, will be immediately noted and investigated. These standards exceed those required for other shipments of hazardous wastes.

Waste Receipt, Unloading, and Verification. The TRUPACT II is designed and certified to transport CH TRU wastes. The waste will be received at the WIPP Waste Handling Building. There, it will be monitored for surface radiation, and if clean, will be unloaded in the receiving and inspection area. Road dust and oil picked up during transport will not require cleaning. Surface contamination by hazardous constituents of the TRUPACT II exterior is not likely to occur.

Special equipment is required to open the TRUPACT II containers. Opening requires that a slight vacuum be created within a TRUPACT II, enough to draw its two halves tightly together so that the top can be turned and lifted off. Because the 14 drums within a TRUPACT II are vented, the air removed by the vacuum pump will be monitored and filtered prior to discharge. The spent filters will be managed as TRU mixed waste in compliance with all applicable regulations.

The bar code will verify the accuracy of the shipping manifest. The bar code data along with the TRANSCOM tracking system verify that the wastes shipped conform to the manifest description. Drums will not be opened and visually examined at the WIPP facility. A manifest discrepancy report will be filed to report anomalies and resolution of such discrepancies prior to emplacement.

Containers exhibiting contamination above allowable limits, or those with signs of damage will be decontaminated, overpacked or repaired, as necessary, prior to emplacement underground. The containers then will be stacked on pallets and transferred underground through the waste-handling shaft.

RH wastes will also be certified and tracked during transportation. The RH TRU wastes will be received in NRC-certified shielded shipping casks. Each cask will contain one canister of waste, and will be handled remotely during removal, inspection, decontamination and, if necessary, overpacking. Manifest information will be verified in the same manner as CH wastes. It then will be loaded into a specially designed facility cask and taken to the underground through the waste-handling shaft.

Wastes Generated During Handling Operations. Air filtering and decontamination procedures are the only waste-generating activities expected during routine waste handling operations. Decontamination of TRUPACT IIs or other containers and equipment will involve the use of solvents on lint-free rags. Used rags will be managed in accordance with all applicable regulations, as will spent filters.

Waste Emplacement. Underground, CH TRU waste will be taken from the waste receiving station and transported to the waste rooms. After a decision is made to begin full-scale operations, the rooms will be backfilled with a crushed salt-based material.

The RH TRU wastes will be horizontally emplaced in holes drilled into the walls of the panels. Initially, the holes will be fitted with steel liners to resist lithostatic pressures so that they can be retrieved if necessary. Steel liners will not be used after full-scale operations are initiated.

6.3 MONITORING PROGRAMS

The DOE will maintain several monitoring programs at the facility. Current and planned monitoring programs are described briefly as follows.

Radiological Baseline Program (RBP). Initiated in 1985, the RBP was designed to establish statistically sound background radiological data against which operational and post-operational radiation measurements can be assessed. It consists of five subprograms to establish the following: (1) atmospheric radiation baseline; (2) ambient radiation baseline; (3) terrestrial radiation baseline; (4) hydrologic radiation baseline; and (5) biotic radiation baseline.

Ecological Monitoring Program (EMP). The EMP was initiated in 1975 to perform nonradiological baseline studies over a wide area prior to the initiation of construction activities. Seven permanent ecological monitoring plots continue to be studied. This program consists of six subprograms: (1) meteorology; (2) air quality; (3) water quality; (4) aerial photography; (5) vertebrate census; and (6) salt impact studies. To date, the EMP has identified no significant impacts attributable to construction of the WIPP facility.

Operational Environmental Monitoring Program (OEMP). The goal of the OEMP is to determine what impacts, if any, will be experienced by the local ecosystem and geographic area as a result of WIPP operations. It is directed at measuring potential radionuclide releases and is similar to the RBP, except that it is more flexible to allow investigation of trends or anomalies.

Occupational Monitoring Program (OMP). The OMP was established to ensure a safe working environment for all personnel involved in waste handling operations. Continuous air monitors for radioactive particulates and explosive gas monitors are located throughout the Waste Handling Building and underground facility. In addition, the underground monitoring system has been integrated into the ventilation system.

Volatile Organic Compounds Monitoring. Air in the underground and in the Air Intake Shaft and Exhaust Shaft will be monitored for the presence of volatile organic compounds to support DOE's demonstration of no-migration of hazardous substances beyond the unit boundary.

TRUPACT II Monitoring. As described, radiation and volatile organics will be monitored during the opening of TRUPACT IIs in the Waste Handling Building. Monitoring of the air evacuated by the vacuum pump will indicate whether any breaching of drums within a TRUPACT II has occurred so that special measures can be taken to prevent releases to the environment or exposures to workers. All air will be filtered for particulates prior to discharge.

Test Phase Monitoring. Standard Operating Procedures specify that, during the conduct of underground experiments during the test phase, gas or other samples will be monitored for radiation and volatile organic compounds prior to being removed from the test area.

Long-Term Monitoring Program. The objective of the Long-Term Monitoring Program will be the detection of substantial and detrimental deviation from established baseline data and expected performance conditions. It will be, in a broad sense, a continuation of preoperational and operational monitoring activities. Additional elements of the program will be developed and implemented on an as-needed basis, with input provided by the results of the test phase and actual conditions during operations.

6.4 PERSONNEL TRAINING

All personnel are thoroughly trained in standard and emergency response procedures. The DOE maintains records indicating the date and type of training received by each employee.

6.5 CONTINGENCY PLANNING AND EMERGENCY PREPAREDNESS

The contingency plan for the WIPP facility addresses potential emergencies involving hazardous constituents and proper response procedures. Local officials, fire fighters and hospital staff have been trained and are prepared to assist in these response actions. The Emergency Plan is provided in Appendix A of the No-Migration Variance Petition.

The WIPP surface facilities include fire protection design features and are equipped with a fire suppression system. The WIPP facility is the only mined excavation equipped with underground fire trucks and mining equipment which include fire suppression equipment. Underground fire prevention is achieved by limiting potential sources of fuel for fire and through the prohibition of pyrophoric material in the waste itself.

6.6 DECOMMISSIONING AND CLOSURE

Decommissioning and closure of the WIPP facility will involve decontaminating and dismantling the surface structures. Underground, the panels, drifts and shafts will be backfilled and sealed. The primary function of the overall seal system is to limit the release of radionuclides and hazardous constituents through man-made penetrations. The seal system will also limit or prevent the inflow of ground water from overlying formations to the Salado Formation. The seal system will include multiple seals to carry out different functions and to allow for redundancy. In general, the sealing program relies on a strategy that combines the use of both short- and long-term seal components. The "short-term" seals employ concretes developed specifically for this application, in addition to swelling clay material (bentonite) that has been shown to be stable and to exhibit low permeability to brines. In the long-term, crushed salt, placed at multiple locations within the shafts and drifts, will reconsolidate as a result of creep closure of the excavations to virtually the same density as the undisturbed rock, and will serve as the final seal component. A detailed description of the seal system components is provided in Section 1.4 of the Addendum to the No-Migration Variance Petition.

Contaminated equipment and debris will be placed underground prior to backfilling. Post-closure care will include continued environmental surveillance and the maintenance of site security markers. The Closure/Post-Closure Plan is provided in Appendix C to the No-Migration Variance Petition.

7.0 ENVIRONMENTAL IMPACTS

The environmental impacts of the WIPP project are described in the petition, as well as in the WIPP Supplemental Environmental Impact Statement (SEIS), which has been previously provided to EPA in draft form for review. The final SEIS and Record of Decision are expected in early 1990.

7.1 POTENTIAL IMPACTS OF ROUTINE RELEASES DURING OPERATIONS

The environmental consequences of routine releases during waste emplacement operations were assessed through a conservative risk assessment, in which personnel above and below ground were assumed to spend each eight-hour day of their entire working lives at the points of maximum concentration. The nearest off-site residential receptors are assumed to be continuously exposed to postulated releases throughout their lifetimes. The hazardous constituents examined in the risk assessment were carbon tetrachloride; methylene chloride; 1,1,1-trichloroethane; 1,1,2-trichloro-1,2,2-trifluoroethane; and lead. Of these, the first two are classified by EPA as carcinogens.

Using the above conservative assumptions, the maximum lifetime excess cancer risk level for occupational receptors is about one hundred times less than the one in 10,000 risk level considered by EPA to be acceptable for workplace exposures. The maximum lifetime excess cancer risk level for the public is about ten thousand times less than the one in 100,000 risk level considered by EPA to be acceptable for public exposure. The maximum estimated intakes of noncarcinogenic chemicals by occupational workers and the public are well below health-based levels, indicating no adverse human health effects from routine exposures to the low concentrations of chemicals released.

7.2 POTENTIAL IMPACTS OF ACCIDENTAL RELEASES DURING OPERATIONS

Potential risks to personnel during several on-site accident events were estimated based on comparison to Threshold Limit Values (TLVs) and Immediately Dangerous to Life and Health (IDLH) criteria. TLVs are standards established to protect workers from eight-hour-per-day exposures throughout their working lives. The IDLH is the maximum concentration in air from which escape within 30 minutes would not result in any impairing symptoms or irreversible health effects. The use of IDLH criteria is conservative because the postulated accident scenarios are short-term events.

The maximum worker exposure to any hazardous chemical was about 1,000 times less than these health-based levels. Similarly, public exposures to hazardous chemicals during accident scenarios also were extremely low, and no adverse human health effects were indicated.

7.3 POTENTIAL IMPACTS OF POST-OPERATIONAL RELEASES

The WIPP surface facility will be decommissioned and the repository sealed as part of the closure process. For the purpose of the risk assessment, engineered barriers such as the shaft seals are assumed to function as designed. The impacts of releases through four pathways are examined in the petition: air, surface water, soils and ground water.

Air Pathway. As wastes are emplaced in a storage panel, it will be backfilled with an absorbent mixture which will retard diffusion of volatilized organics into the repository environment and surrounding salt medium. The shafts also will be sealed with a seal designed to withstand uncertainties in predicted geological behavior. There is no reasonable mechanism for the release of gases to the atmosphere above the repository in the short term.

Throughout the first hundred years after closure, the salt surrounding the excavation will flow inward, eventually encasing the waste. Lithostatic pressure of slightly more than 2,000 psi will be reestablished in the disturbed area. At this time, gases generated through radiolysis, microbial decomposition and other transformation mechanisms will no longer have a driving mechanism for diffusion into the salt of the Salado. Diffusion of gases during the period preceding the return to lithostatic pressure will not reach the unit boundary, as the average gas permeability of the rock is about one foot per 23,000 years. No significant impacts via the air pathway are indicated.

Surface Water Pathway. A few unnamed drainage channels exist within 50 miles of the WIPP facility, and no natural drainage features exist at the site. The site has been graded to provide interceptor diversions to channel storm runoff away from the surface structures. The nearest river is the Pecos, 14 miles to the west. The Mescalero caliche forms a highly impermeable caprock over the area, and there is no hydrologic communication between the Salado Formation and any surface water bodies. There also is no driving mechanism which would allow waste to migrate from the repository to any other formation hydrologically connected to surface water. No credible surface water pathway has been identified.

Soils Pathway. There is no credible mechanism by which surface soils can become contaminated after operations. The wastes will be located more than 2,000 feet underground.

Ground Water Pathway. Examination of impacts associated with the ground-water pathway required examining the rate at which hazardous constituents would potentially move through the storage panel, drifts, and seals, along the underlying Marker Bed 139, and up through the Waste Handling Shaft. Movement through the ERDA-9 borehole, the closest borehole to the waste, also was considered.

The SWIFT III computer code was used in performing the modeling. Several conservative conditions were assumed to eliminate any possibility of underestimating the travel time of contaminants:

- A one-dimensional system was assumed. The contaminant plume was constrained to move along one axis only; lateral diffusion was not allowed. Gravity effects were ignored which would otherwise impede the progress of the plume. The overall hydraulic gradient was, in effect, increased by more than 150 percent through this assumption, causing the waste to advance half again faster than it would under a more realistic approach.

- The effects of the panel and marker bed seals were ignored. These represent several meters of highly impermeable material, and excluding them from the analyses increased the modeled travel time by several thousand years. This assumption is strongly conservative.

- The contaminant source was assumed to have a constant concentration of pure chemical waste. It was considered 100 percent soluble and to not deplete over time. This is an extremely conservative assumption.

- The permeability assigned to the marker bed was much higher than that of coarse gravel, and was considered essentially to be a nonresisting segment of the flow path.

- Extremely high dispersivities throughout the flow path were assumed. This maximized the forward advance of the contaminant plume and represents a strongly conservative assumption.

- No retardation of waste is assumed; its velocity is considered to be the same as the average brine velocity. Factors that would slow velocity, such as degradation, chemical reaction, sorption and ion exchange, were excluded from consideration. Again, the assumption is strongly conservative.

Waste migration was simulated along the pathway involving the Waste Handling Shaft. Three different values of dispersivity were used. The most conservative dispersivity value caused the ten-parts-per-trillion concentration level of the hypothetical chemical waste to advance to a position, after 10,000 years, of 1,706 feet away from the source. This would be 807 feet below the uppermost boundary of the Salado Formation and, in fact, is still within the shaft seal. A more realistic, but still conservative, dispersivity value caused the ten-parts-per-trillion concentration level to have not reached the shaft at all. The ten-parts-per-trillion value was selected arbitrarily as a modeling target; ten parts per trillion is far below the lower-most detection limit of any hazardous constituent for which standard analytical methods have been established.

Additional modeling was performed to examine movement along the path involving the ERDA-9 borehole. The borehole will be sealed to permeabilities equivalent to those to be obtained in the shafts. Using a conservative value for dispersivity, the ten-parts-per-trillion isopleth would migrate 1,024 feet from the source, and would still be 1,115 feet below the top of the Salado.

In conclusion, waste mobility modeling based on extremely conservative assumptions about the characteristics of the waste and the disposal system show that hazardous constituents will not migrate beyond the WIPP unit boundary, defined in the petition as the uppermost extent of the Salado Formation. The modeling effort can be refined based on actual data obtained from experiments, but the results can realistically be expected to lead to even slower travel times.

8.0 UNCERTAINTY ANALYSIS

The uncertainty analysis involves the prediction and assessment of infrequent or unexpected events that could adversely impact the integrity of the disposal unit. Natural events, waste- and facility-induced events, and human-induced events were examined in the petition, and none were found to pose a significant threat to the WIPP facility.

8.1 NATURAL EVENTS

Flooding, tornadoes, range fires, meteorites, erosion, dissolution and sedimentation each were evaluated with regard to impacts. Either because of the very low likelihood of their occurrence, or because of protective features incorporated into the design of the surface and underground structures, none of these hypothetical events poses a significant impact to the WIPP facility.

8.2 WASTE- AND FACILITY-INDUCED EVENTS

Waste- and facility-induced events include the thermal and chemical effects of the wastes, the mechanical effects of the facility, changes in the hydrologic regime, and waste fires. Impacts from these events are negligible, largely because of the unlikelihood of their occurrence, with the exception of impacts from the generation of gases in the repository.

The impacts of potential gas generation within the repository cannot be fully addressed at this time. The most important factor with regard to impacts is the rate at which gases will be produced; to a certain degree, gases will be absorbed into the salt of the Salado. The results of experiments conducted during the test phase will help to quantify the rate of gas generation within the repository and will determine whether additional safeguards or barriers are needed to meet long-term performance goals. Several engineered components can be added to the system to mitigate the impacts of gas generation, and these will be evaluated and incorporated as necessary. Permanent emplacement operations will not begin until it is demonstrated that the WIPP meets established performance requirements regarding the isolation of the waste from the environment.

8.3 HUMAN-INDUCED EVENTS

The potential impacts of general human-induced events summarized here address facility design, construction, and operation; shaft seal failure; and human intrusion into the repository. These and other scenarios are described in the petition.

All portions of WIPP facility design, construction, and operation have been and will continue to be carried out under a strict Quality Assurance (QA) program, which meets the federally-mandated requirements for nuclear facilities. In view of documented enforcement of the QA program, it is considered unlikely that any aspect of the design or operation could impact the integrity of the repository.

In the unlikely event of failure of the shaft seals, a scenario has been evaluated wherein water leaks through the failed shaft seal into the repository. The water comes in contact with the waste and occupies the remaining available void space in the repository. The continued closure of the excavations may then pressurize the brine and force fluid up through the failed shaft seals. Three factors significantly reduce the likelihood of this scenario:

- Consolidated shaft seals are expected to create a mass comparable to the intact salt mass and a condition approaching its undisturbed state.
- Presence of effective panel seals provide substantial resistance to flow through the repository, limiting possible waste-water interactions.
- Consolidated nonwaste drift backfill serves as a redundant barrier to fluid migration.

The repository is isolated from humans by more than 2,000 feet of rock. Before closure, access to the repository will be controlled with fences and remote monitoring equipment. After closure, the boundaries of the site will be delineated with markers placed to serve as warning devices. All state and county planning, deed and record offices, oil and gas commissions, and other affected agencies will be notified of the location of WIPP boundaries so that unknowing parties seeking access will be informed as to the restrictions placed on use of the site. In addition, the site will remain under federal jurisdiction in perpetuity.

9.0 CONCLUSIONS

The Congress enacted stringent new laws in 1984 to prohibit the land disposal of hazardous wastes unless they first meet standards (typically expressed as concentrations or as a required method of treatment). To obtain a variance from these restrictions, the owner or operator of a land disposal facility is required to demonstrate that, to a reasonable degree of certainty, there will be no migration of hazardous wastes beyond the unit boundary for as long as they remain hazardous. EPA relies on health-based standards as the basis for evaluating such demonstrations, along with other stringent criteria outlined in its guidance manual.

The WIPP facility relies on both the inherent characteristics of the salt in which the repository is constructed and engineered barriers, such as backfill and seals, to permanently isolate the wastes that will be emplaced, as well as operational procedures that protect workers and the public during waste emplacement activities. The DOE believes that the No-Migration Variance Petition demonstrates, to the necessary degree of certainty, that there will be no releases of hazardous constituents from the WIPP facility.

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